EXECUTION PHASE
PROJECT PLAN
FOR
GEOSTATIONARY OPERATIONAL
ENVIRONMENTAL SATELLITES
(GOES-NO/PQ)

April 1999

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

EXECUTION PHASE PROJECT PLAN FOR THE
GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE
(GOES)-NO/PQ PROJECT

Agreements:

Original signed by Martin A. Davis on April 7, 1999

Martin A. Davis — Date
GOES Project Manager

_Original signed by Martin A. Davis on April 7, 1999

Martin A. Davis — Date
GOES Program Manager

_Original signed by A. V. Diaz on July 2, 1999

A. V. Diaz — Date
Director
Goddard Space Flight Center

Table of Contents

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
EXECUTION PHASE
PROJECT PLAN
FOR
GEOSTATIONARY OPERATIONAL
ENVIRONMENTAL SATELLITES
(GOES-NO/PQ)

FORWARD

This Execution Phase Project Plan is the Goddard Space Flight Center (GSFC) Plan for the Geostationary Operational Environmental Satellites (GOES-N through Q) Project. This Project Plan is issued in compliance with NASA Procedures and Guidelines (NPG)-7120.5.

It is the responsibility of the GSFC GOES Project Manager to keep this project plan up-to-date by timely revisions as substantive changes occur.

ACRONYMS AND ABBREVIATIONS

ACE	Attitude Control Electronics
ADS	Angular Displacement Sensor
AEC	Able Engineering Company
ATN	Advanced Tiros-N
ATS	Applications Technology Satellite
BPDU	Bus Power Distribution System
BVC	Bus Voltage Controllers
CCD	Charge Coupled Device
CCR	Configuration Change Request
CDAS	Command and Data Acquisition Station
CDRL	Contract Deliverable Requirements Listing
CFE	Contractor Furnished Equipment
COTS	Commercial Off-the-Shelf
CTCU	Central Telemetry and Command Unit
DCP	Data Collection Platform
DCPI	Data Collection Platform Interrogation
DCPR	Data Collection Platform Report
DCS	Data Collection System
DOC	Department of Commerce
DPU	Data Processor Unit
DSN	Deep Space Network
ECRA	Electrical Contact Ring Assembly
ELT	Emergency Locator Transmitter
EMWIN	Emergency Managers Weather Information Network
EPS	Energetic Particle Sensor
EPEAD	Energetic Proton, Electron and Alpha Detector
ESD	Electrostatic Discharge
EUV	Extreme Ultra Violet Sensor
ETR	Eastern Test Range
eV	Electron Volts
E-W	East-West
FOV	Field of View
FRB	Failure Review Board
GFE	Government Furnished Equipment
GGSM	GOES Ground Systems Manager
GOES	Geostationary Operational Environmental Satellite
GPD	Goddard Policy Directive
GPG	Goddard Procedures and Guidelines
GSFC	Goddard Space Flight Center

GTACS	GOES-NO/PQ Telemetry and Command System
GTO	Geostationary Transfer Orbit
GVAR	GOES Variable Format
HASS	High Accuracy Sun Sensor
HEPAD	High Energy Proton and Alpha Detector
HIRU	Hemispherical Inertial Reference Unit
HSC	Hughes Space and Communications
Hz	Hertz (cycles per second)
IMC	Image Motion Compensation
INR	Image Navigation and Registration
IPC	Integrated Power Controller
IPDU	Instrument Power Distribution Unit
IPV	Independent Pressure Vessel
IR	Infrared
ISI	Integral Systems Inc.
ITO	Indium Tin Oxide
ITT/ACD	ITT/Aerospace Communications Division
JPL	Jet Propulsion Laboratory
K	Kelvin (degrees)
Kg	Kilograms
KBPS	Kilobits per second
KSC	Kennedy Space Center
LAM	Liquid Apogee Motor
LM	Lightning Mapper
LMATC	Lockheed Martin Advanced Technology Center
LOR	Launch Orbit Raising
LRD	Launch Requirements Document
LTT	Low Thrust Thrusters
LVC	Low Voltage Controller
MA	Mission Assurance
MAGED	Magnetospheric Electron Detector
MAGPD	Magnetospheric Proton Detector
MEPED	Medium Energy Proton and Electron Detector
MDL	Multi-use Data Link
MLI	Multi-Layer Insulation
MMH	Mono-Methyl-Hydrazine
MOM	Mission Operations Manager
MPS	MDL Processing System
MRB	Material Review Board
MSFC	Marshall Space Flight Center

N	Newton or North
N2O4	Formula for Nitrogen Tetroxide
NASA	National Aeronautics and Space Administration
NEDT	Noise Equivalent Change to Temperature
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NOATS	GOES-NO/PQ Orbit and Attitude Tracking System
NOMSS	National Operational Meteorological Satellite System
NPG	NASA Procedures and Guidelines
NT	nanoTesla
NTACTS	GOES-NO/PQ Telemetry Acquisition and Command Transmission System
NWS	National Weather Service
N-S	North-South
OATS	Orbit and Attitude Tracking System
OGE	Operational Ground Equipment
OMTPE	Office of Mission to Planet Earth
ORA	Office of Research and Applications (NESDIS)
OSD	Office of Systems Development (NESDIS)
OSDPD	Office of Satellite Data Processing and Distribution (NESDIS)
OSO	Office of Satellite Operations
PAF	Payload Attach Fairing
PCA	Program Commitment Agreement
PCC	Program Cost Commitment
PLF	Payload Fairing
PLT	Post Launch Test
PMC	Program Management Council
PMD	Propellant Management Device
PMT	Photomultiplier Tube
RF	Radio Frequency
RTCU	Remote Telemetry and Command Unit
SARSAT	Search and Rescue Satellite Aided Tracking
SAIC	Science Applications International Corporation
SAM	Systems Assurance Manager
SAO	Systems Acquisition Office (NOAA)
SDU	Squib Driver Unit
SEC	Space Environment Center (NOAA)
SEM	Space Environment Monitor
S/N	Signal to Noise Ratio
SPS	Sensor Processing System

SSAA	Short Span Attitude Adjustment
SSGS	Spacecraft Support Ground System
SXI	Solar X-Ray Imager
TBD	To Be Determined
T&C	Telemetry and Command
rad	Microradian
WCDAS	Wallops Command and Data Acquisition Station
WEFAX	Weather Facsimile
XRCF	X-Ray Calibration Facility
XRP	X-Ray Positioner
XRS	X-Ray Sensor

EXECUTION PHASE
PROJECT PLAN
FOR
GEOSTATIONARY OPERATIONAL
ENVIRONMENTAL SATELLITES
(GOES-NO/PQ)

1.0 INTRODUCTION

1.1 IDENTIFICATION

Geostationary Operational Environmental Satellites NO/PQ is the Project title designated by the National Aeronautics and Space Administration (NASA) Headquarters and Goddard Space Flight Center (GSFC) which provides for the procurement, launch, and activation/evaluation of the GOES satellites. This effort is being funded under Unique Project Number (UPN) 616-4.

1.2 BACKGROUND

NASA and the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce (DOC) are involved in a joint effort, which allows for the continuation of the GOES System as described in Appendix A.

Over the past 35 years, environmental service agencies have stated a need for near continuous, timely, high quality observations of the Earth and its environment. In 1961 an interagency plan for a National Operational Meteorological Satellite System (NOMSS) was submitted to the President. The plan recommended that a geostationary satellite be added to the operational system to meet these needs when technology and resources become available. The satellites being procured are logical extensions for the program that was started in 1974 with the launch of the Synchronous Meteorological Satellite (SMS-A).

The office within the DOC agency responsible for managing this program is NOAA. Within NOAA, responsibility for the program has been delegated to the System Acquisition Office (SAO). Consistent with the plan described above, NASA and NOAA are actively engaged in a cooperative program to continue the GOES system with the launch of the GOES-NO/PQ satellites.

NASA’s GSFC is responsible for the procurement, development, and verification testing of the spacecraft, instruments, and unique ground equipment.

NOAA is responsible for the in-orbit operation of the system including determining the need for satellite replacement.

NASA and NOAA are jointly involved in the design, development, installation, and integration of the ground system that is needed to acquire, handle, process, and disseminate the data from the sensors on the GOES-NO/PQ satellites.

1.3 SUMMARY

The GOES system is designed to acquire and disseminate environmental data from a near-equatorial Earth orbit at geostationary altitude. This includes making the measurements of the Earth’s atmosphere, its surface, cloud cover and the solar and geosynchronous space environment. Major functions of the GOES system are to support the Imager, Sounder, Solar X-Ray Imager, and SEM instruments. Other functions of the GOES system are to: (1) Support a collection of terrestrial and oceanographic Data Collection Platforms (DCP’s); (2) Relay Weather Facsimile (WEFAX) and imaging and sounding data between earth terminals; (3) Relay the Emergency Manager’s Weather Information (EMWIN) broadcast; and (4) Provide rapid detection of distress messages from Emergency Locator Transmitters (ELT’s).

2.0 OBJECTIVES

2.1 PROGRAM OBJECTIVES

The GOES-NO/PQ Program objectives are as follows:

a) Provide environmental data that will be used to produce routine meteorological analyses and forecasts
b) Maintain continuity of services to the user agencies
c) Provide environmental data that can be used to expand knowledge of mesoscale and synoptic scale storm development and provide data that may be used to help in forecasting these severe weather events
d) Contribute to the development of domestic and international in-situ environmental warning services and enhancements of basic environmental services
e) Provide for the reception of early emergency distress signals to aid the Search and Rescue Satellite Aided Tracking (SARSAT) operation
f) Improve the capability for forecasting and providing real-time warning of solar disturbances
g) Provide data that may be used to extend knowledge and understanding of the atmosphere and its processes (e.g., by viewing the evolution and motion of storms and other atmospheric phenomena) in order to improve short/long-term weather forecasts

2.2 PROJECT OBJECTIVES

The objective of the GOES NO/PQ Project is to procure, develop, test, launch and activate GOES-NO/PQ satellites that meet NOAA requirements.

2.3 MISSION OBJECTIVES

The primary objectives of the GOES mission are to:

a) Maintain continuous service from a GOES system that meets the remote sensing requirements as specified by NOAA; that is, to provide for continuous observations of the Earth and its atmosphere from a geosynchronous orbit
b) Provide a satellite and Spacecraft Support Ground System (SSGS) designed to permit acquisition and dissemination of: 1) Imaging data, 2) Sounding data independent of the Imaging data and 3) Space Environment Monitor (SEM) data
c) Provide a satellite platform suitable for supporting the imaging requirements of the Solar X-Ray Imager (SXI)

d) Provide for reception and relay of data from ground based Data Collection Platforms (DCP) to the NOAA Command and Data Acquisition (CDA) ground station
e) Provide for continuous relay of weather facsimile (WEFAX) and other data to small users, independent of all other functions
f) Permit relay of distress signals from aircraft or marine vessels to the Search and Rescue ground stations of the SARSAT
g) Provide a spacecraft capability for permitting data transmission via the EMWIN
h) Provide spacecraft resources to allow for an instrument of opportunity to be accommodated without major spacecraft redesign

2.4 LEVEL 1 PERFORMANCE REQUIREMENTS

2.4.1 General

The Level 1 performance requirements for the GOES-NO/PQ project are compiled and identified below. The requirements were prepared by updating the GOES-I/M performance requirements that are described in the GOES-I/M Project Plan. These requirements serve as the baseline for derivation of lower level performance requirements.

These Level 1 requirements are controlled by NOAA. For those issues that require Level 1 decisions, the procedures defined in the GOES-NO/PQ Program Configuration Control Plan, S-415-CM-01 (415-PG-1410.1.1) will be used.

2.4.2 System Requirement

The GOES-NO/PQ satellites shall be designed to provide an economical and stable platform for the instruments to be used in making measurements of the earth’s atmosphere, its surface, cloud cover and electromagnetic environment.

2.4.2.1 System Elements

The system elements consisting of the flight segment, launch ground segment, and the on-orbit ground segment are described below.

2.4.2.1.1 Flight Segment

The flight segment will include the spacecraft bus, its support subsystems, the operational instruments, and the propulsion subsystem. The propulsion subsystem is required to transfer the satellite from the geostationary transfer orbit to its final station in geostationary orbit, and to maintain station keeping during the in-orbit lifetime of the satellite.

2.4.2.1.2 Launch Ground Segment

The spacecraft contractor will provide for the ground network required for launch support functions.

2.4.2.1.3 On-Orbit Ground Segment (Provided by NOAA)

The on-orbit ground segment will consist of the:

a) NOAA Satellite Operations Control (SOCC) facility
b) NOAA Command and Data Acquisition (CDA)
c) Back-up CDA station for supporting spacecraft operations
d) NOAA Central Data and Distribution Facility for data processing and dissemination
e) NOAA Space Environment Center (SEC) for processing and distribution of data from the SEM instruments and the SXI Imager instrument.

2.4.3 GOES-I/M Interface Compatibility

The spacecraft interfaces to the following data users shall remain compatible with the existing GOES-I/M system.

a) Data Collection
b) Search and Rescue
c) GOES Variable Format(GVAR)

2.4.4 Simultaneous Imager and Sounder Operation

Imaging and sounding data product services shall be provided throughout the twenty-four hour day. Independence of functions is required so that imaging and sounding may be accomplished in an essentially parallel, simultaneous mode.

2.4.5 Imager Performance Requirements

2.4.5.1 General

The Imaging channel requirements shall be as described in Table 6.1.13-3.

2.4.5.2 Data Timeliness

The GOES-NO/PQ design should minimize conflict between synoptic and mesoscale users of data. Imaging the Earth with each of the five Imager channels (within 60 degrees of great circle arc of the sub-point) in 20 minutes or less shall be required. When full Earth images, as defined above, are not required, it shall be practical to obtain data from limited geographic areas at an equivalent line rate (i.e., 50 degrees North to 25 degrees North in 4-5 minutes). Earth location data for each image shall be available to the end product user within 3 minutes of initiation of image data acquisition.

2.4.6 Sounder Performance Requirements

2.4.6.1 Sounder Channel Requirements

The central wavenumber, bandwidth, and noise equivalent radiance of each sounding channel shall be as specified in Table 6.1.14-1. The parameters shall apply to the overall electro-optical system configuration operating under nominal environmental conditions. The Sounder shall be a discrete stepping line-scan instrument designed to measure scene radiation in 19 channels.

2.4.6.2 Atmospheric Sounding

The Sounder capability shall provide data that will be used by NOAA to determine the vertical temperature of the atmosphere from the Earth's surface to the stratosphere and moisture vapor content profile from the surface to near the tropopause.

2.4.7 Image Navigation and Registration

2.4.7.1 Imager Earth Location Requirements

Navigation accuracy of the GOES-NO/PQ imagery should provide a capability to measure cloud displacements between two successive images obtained 30 minutes apart to an accuracy of two to three meters per second. This requires a capability to co-register centroids of the field of view during the separation periods described below.

Table 2.4.7-1 Imager Frame-to-Frame Registration

Separation Period	Registration Requirement
15 minutes	28 ìrad
90 minutes	42 ìrad
24 hours	112 ìrad

2.4.7.2 Imager Channel-to-Channel Co-registration

At any scan location, the relative positions of the centroids of the visible and infrared imaging channel IGFOV's shall be within a circle of 28 ìrad radius under either dynamic (active scan) or static conditions (scan stopped).

2.4.7.3 Sounder INR Requirements

The Sounder frame-to-frame registration requirements shall be as described below.

Table 2.4.7-1 Sounder Frame-to-Frame Registration

Separation Period	Registration Requirement
90 minutes	84 ìrad
24 hours	224 ìrad

2.4.8 Space Environment Monitor

2.4.8.1 General

The Space Environment Monitor (SEM) shall provide the ability to monitor magnetic fields, assess solar x-ray flux and sense energetic particles.

2.4.8.2 Magnetometer

The magnetometer shall consist of redundant biaxial flux-gate sensor elements with associated single string signal processing electronics. Data transmitted from the spacecraft shall allow the real-time determination of the magnitude and direction of the ambient field in an Earth-referenced coordinate system.

2.4.8.3 Solar X-Ray Sensor

Two X-Ray channels are required to observe solar fluxes in the 0.05 to 0.4 nm and the 0.1 to 0.8 nm bands respectively. At least five EUV channels are required to observe solar fluxes in the 10-125 nm range.

2.4.8.4 Energetic Particle Sensors

2.4.8.4.1 Energetic Proton, Electron, and Alpha Detector

An Energetic Proton, Electron, and Alpha Detector (EPEAD) sensor shall be provided that has a solar proton measurement range between 0.8-500 MeV, and alpha particle measurement range between 3.2-400 MeV. The instrument shall provide electron flux measurements in the energy range from 30 KeV to greater than 4 MeV.

2.4.8.4.2 Magnetospheric Particle Sensors

A Magnetospheric Electron Detector (MAGED) shall be provided to measure electron flux in the energy range from 30 to 600 MeV. A Magnetospheric Proton Detector shall also be provided to measure proton flux in the energy range from 80 KeV to 800 KeV.

2.4.8.5 High Energy Proton and Alpha Detector

The High Energy Proton and Alpha Detector (HEPAD) instrument shall be capable of performing measurements of the proton flux above 350 MeV and of the alpha particle flux above 640 Mev/nucleon.

2.4.8.6 Solar X-Ray Imager

The Solar X-Ray Imager (SXI) instrument shall be designed for a minimum in-orbit life time of 3 years, with a goal of 5 years of on-orbit operation after an on-orbit storage period of up to 2 years.

The instrument shall be designed to provide images of the solar corona in the soft X-Ray to far ultra-violet region (0.6 to 6 nm) of the electromagnetic spectrum.

2.4.9 Communications System

2.4.9.1 General

The satellite communications system shall be capable of providing the data product services that are described below.

2.4.9.2 Data Collection System

The Data Collection System (DCS) shall be capable of interrogating platforms and receiving data from these or other appropriate non-interrogatable platforms. Characteristics of this system, such as platform capacity, RF frequency and bandwidth, and data rate, shall be unchanged from that of the current generation GOES-I/M satellites. The intent here is to make the change in satellites essentially transparent to the data collection community. The DCS features that are to be retained from the GOES-I/M project with no changes are 1) DCP Interrogation Characteristics and 2) DCP Report Characteristics.

2.4.9.3 Search and Rescue System

The satellite shall provide a Search and Rescue (SAR) transponder system. The up-link frequency band shall be between 406.000 to 406.100 mHz. The down-link frequency shall be at 1544.500 mHz.

2.4.9.4 WEFAX Data Transmission Service

The WEFAX system shall be upgraded from the GOES-I/M analog format to a digital format.

2.4.9.5 Emergency Managers Weather Information Network

A spacecraft S-Band data link shall be provided to permit transmission of low-resolution images and other weather information for the Emergency Managers Weather Information Network (EMWIN).

2.4.10 Power Subsystem

The power subsystem solar array and battery shall provide sufficient energy to support any operating mode continuously during any 24-hour day.

2.4.11 Satellite Operations

2.4.11.1 Satellite Lifetime

The satellite lifetime shall be designed to provide 5 cumulative years of on-orbit lifetime plus 2 cumulative years of on-orbit storage, following terrestrial storage for up to 5 years.

2.4.11.2 Spacecraft Orbit

The operational locations for the GOES-NO/PQ satellites shall nominally be at 75 +/- 0.5 degrees west longitude for GOES East and 135 +/- 0.5 degrees West longitude for GOES West. The orbit inclination is specified to be +/- 0.5 degrees.

2.4.12 Data Products

2.4.12.1 Data Production

Production of all operational data products required for satellite post-launch checkout and NOAA routine operations is the responsibility of NOAA.

2.4.12.2 Data Archiving and Dissemination

NOAA has the responsibility to process, analyze, disseminate, and archive all operational data. These data are made available to NASA researchers and others for purposes of research and environmental applications. The GSFC GOES Project Office does not have functional responsibility for reducing and analyzing data for presentation to the scientific community.

NOAA’s Central Data and Distribution Facility (CDDF) at the World Weather Building in Camp Springs, Maryland and the

Space Environment Center (SEC) in Boulder, Colorado will disseminate the data.

3.0 CUSTOMER DEFINITION

The customer for the GOES Satellites and data products is the National Oceanic and Atmospheric Administration (NOAA) that is an organization within the Department of Commerce (DOC). Within NOAA, responsibility for the program has been delegated to the Systems Acquisition Office (SAO). The specific organizations within NOAA that share an interest in the GOES Program are indicated below.

a) Systems Acquisition Office (SAO)
b) National Environmental Satellite, Data, and Information Service (NESDIS):
   - Office of Satellite Operations (OSO)
   - Office of System Development (OSD)
   - Office of Research and Applications (ORA)
   - Office of Satellite Data Processing and Distribution (OSDPD)
c) National Weather Service (NWS)
d) Space Environment Center (SEC)

The following activities are performed in order to ensure customer coordination and involvement in the GOES Program.

a) A NOAA liaison office is co-located within the GOES Program Office where they have daily contact with key project personnel
b) Personnel from the SAO and NESDIS routinely attend the GOES Project Status Reviews with the spacecraft contractor and GFE instrument contractors. This forum is an opportunity for the customer to express their views on project status, issues, problems, or concerns
c) Monthly meetings are held between the GOES Program Office and key personnel from the SAO and NESDIS to discuss mutual concerns and/or issues

4.0 PROGRAM AUTHORITY

Lead Center - Goddard Space Flight Center
GPMC - NASA Headquarters Program Management Council
Program Manager - Mr. Martin Davis / GSFC

5.0 MANAGEMENT

5.1 ORGANIZATIONAL RESPONSIBILITIES

The NASA management responsibilities and procedures for the GOES-NO/PQ Project are in accordance with NASA policy and guidance. The division of responsibilities between NASA and NOAA will be in accordance with NOAA-NASA Basic Agreement of 1998 and the GOES specific Memorandum of Agreement described in Appendix A.

5.2 PROGRAM MANAGEMENT AND ORGANIZATION

NASA Headquarters has delegated program management responsibility to the Goddard Space Flight Center. The NASA organization chart is included as figure 5.2-1. Within GSFC, the Flight Projects Directorate has responsibility for the GOES Program. The GSFC organization chart is shown in figure 5.2-2

The GOES Program has full responsibility for the successful implementation of two NOAA projects, GOES-I/M and GOES-NO/PQ. The program manager and his deputies manage both projects, rather than having a separate project manager for each project. To the extent practicable, the technical and administrative staffs of the two projects are separate and distinct. The Program is responsible for the spacecraft, instruments, launch services and ground system. The organization chart for the GOES Program is given in Figure 5.2-3

The Kennedy Space Center (KSC) is responsible for providing insight into the contractor provided launch services as described in Appendix C.

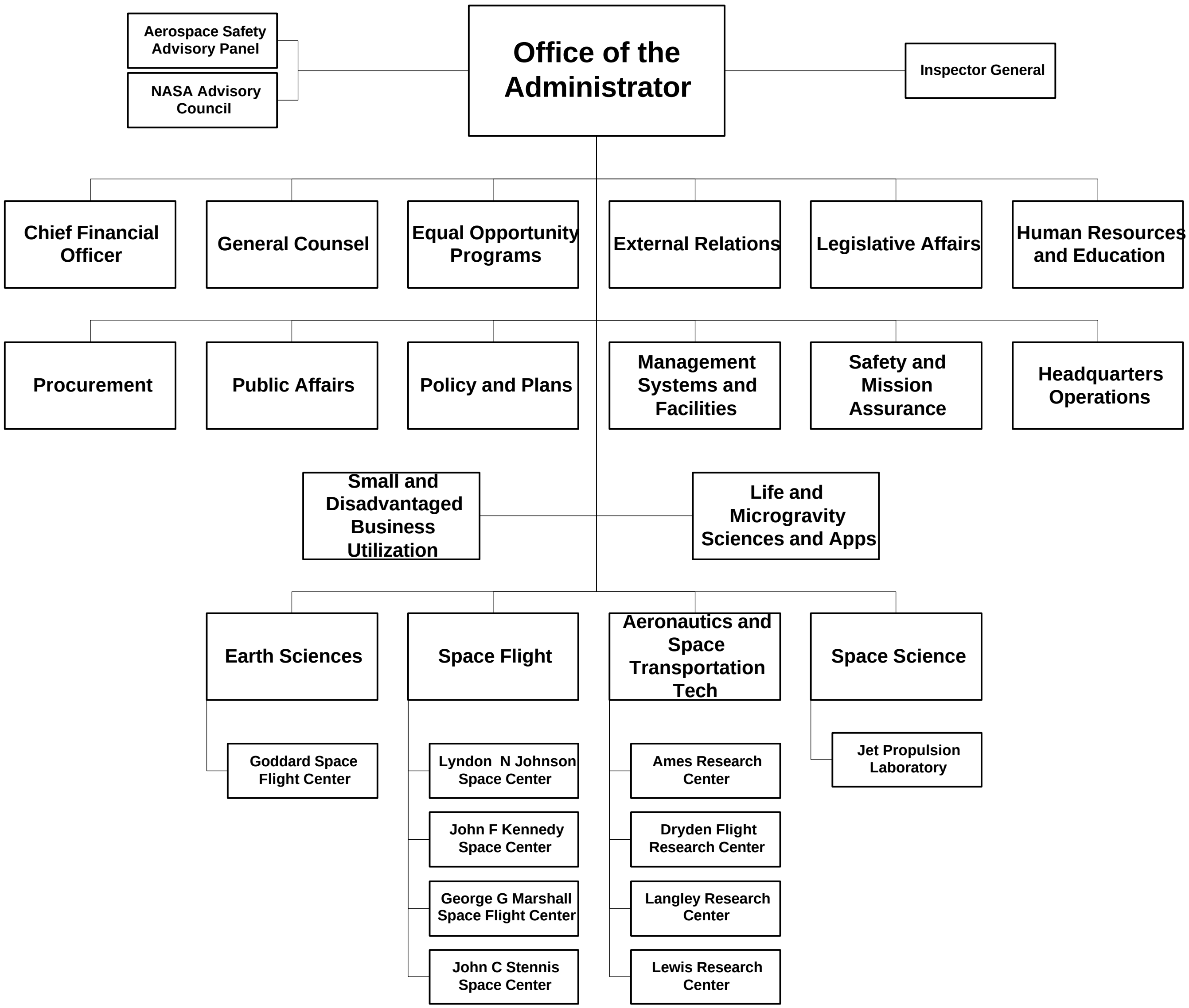


Figure 5.2-1, NASA Organization Chart

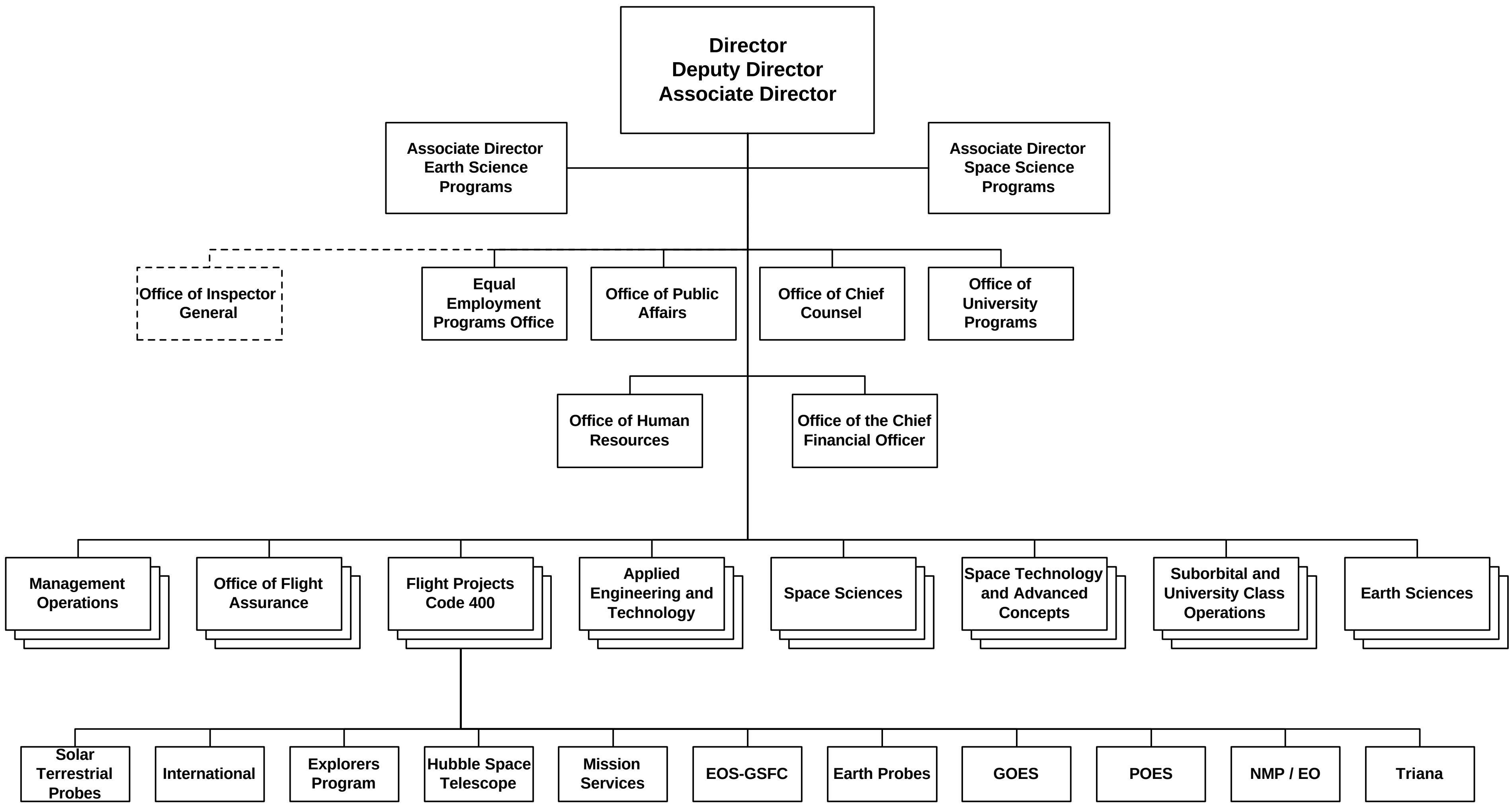


Figure 5.2-2, Goddard Space Flight Center Organization Chart

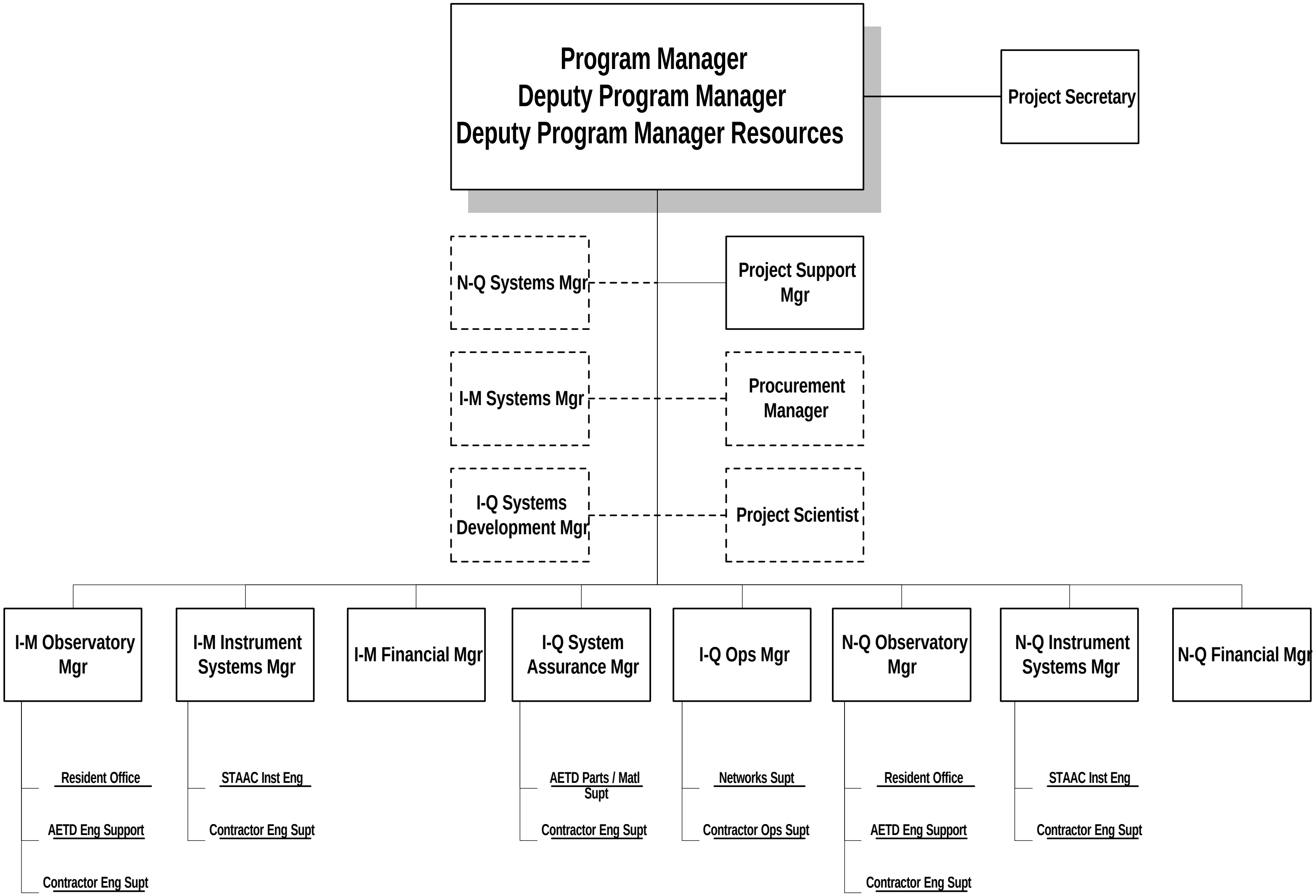


Figure 5.2-3, GOES Program Organization Chart

5.2.1 Program Manager

The Program Manager is responsible for the performance of all necessary functions to ensure the total management of the Program. In particular, he/she is responsible for the planning and evaluation; systems safety; systems tests; configuration management; systems integration, tests, reliability, and quality assurance; spacecraft compatibility with the launch vehicle; integrity of the spacecraft to meet mission requirements; scheduling; health and safety; budgetary and financial planning; technical monitoring of contracts; life-cycle logistics cost, and project reporting. The Program Manager has full authority to carry out these functions, subject to limitations established by the GSFC Director. The Program Manager is also the Project Manager, and discharges his/her responsibilities with the assistance and support of individuals and organizations assigned either administratively or functionally to the project management organization.

5.2.2 Deputy Program Manager

The Deputy Program Manager (DPM) is responsible to the Program Manager, and is an integral member of the management team. He/she supports the Program Manager in directing all phases of the Project, and has project-wide responsibility for personnel management and planning, and evaluating all Project activities on a day-to-day basis. He/she provides technical management to the team of technically skilled specialists and their supporting personnel in order to meet cost and schedule commitments. In the absence of the Program Manager, the DPM assumes full responsibility for program management.

5.2.3 Deputy Program Manager/Resources

The Deputy Program Manager/Resources (DPM/R) is responsible to the Program Manager, and is an integral member of the management team. He/she contributes business management expertise to the establishment of technical program objectives and is responsible for the application of business, financial management, and performance measurement techniques to the accomplishment of those objectives. The DPM/R supervises a team of specialists in the areas of finance, budget, performance measurement, scheduling, pricing, configuration management, etc., and is responsible for the application of sound business techniques to the accomplishment of Project objectives. In the absence of the Program Manager and DPM, the DPM/R acts for the Program Manager.

5.2.4 Systems Manager

The Systems Manager is responsible for optimizing all systems aspects of the flight and ground segments. He/she is responsible for developing the systems design of the flight segment and for ensuring that it is compatible with the scientific instruments, launch vehicle, communications system, ground segment, reliability objectives, and end products. He/she establishes interface constraints and requirements for subsystems, resolves interface and system-level performance questions and problems. He/she reviews performance data and measurements throughout the project to ensure that flight and ground segments meet stated requirements and objectives. Specifically, the Systems Manager has review and sign-off responsibilities for all major system-level functional performance and design specifications; he/she performs risk assessments and evaluates design margins and adequacies; reviews all major test plans and procedures; compares predicted and actual performance of the system; reports routinely to the Project Manager on the status of system engineering activities; serves as chairperson for major failure review committees, and advises the Project Manager as to major (critical) aspects of his assignment. He/she is responsible for suggesting the use of new technical approaches to the project after having determined the risk involved.

5.2.5 Observatory Manager

The Observatory Manager marshals and directs the efforts of a team of government, contractor and industry specialists to identify observatory requirements, in developing subsystems and systems capable of fully meeting those requirements, and in demonstrating that the spacecraft/observatory and its components meet its functional performance goals in the launch and space environments. He/she ensures that the facilities, tools, fixtures, test equipment and ADP hardware and software required in the fabrication, assembly, integration, and test of the subsystems and of the spacecraft/observatory are procured or developed and are available at the appropriate times and places. The Observatory Manager is responsible for planning and managing these tasks so that they are completed on schedule and within the available resources. He/she is the Contracting Officer’s Technical Representative (COTR) for the spacecraft contract.

The Observatory Manager also interfaces with the KSC lead person for insight into launch services.

5.2.6 Instrument Systems Manager

Instrument Systems Manager is responsible for close liaison and monitoring of the instrument development or other types of payload hardware development being performed by other GSFC directorates or outside GSFC, such as universities and contractors. He/she must ensure through coordination and technical review of the payload designs that the instruments or payload hardware meet the technical performance, cost and schedule parameters for the basic mission requirements. He/she is responsible for coordinating the spacecraft bus/payload interfaces and for providing the related ground support equipment, and for assuring that scientific algorithm development, in conjunction with the Project Scientist, is completed in a timely manner.

5.2.7 Project Scientist

The Project Scientist provides scientific guidance to the Project and is the embodiment of the scientific objectives of the Project. He/she is responsible for assuring the satisfactory accomplishment of the scientific objectives of the mission. He/she is an integral part of the project management team, acting as a bridge between the project and the science community. As such, he/she is consulted on all decisions and processes that in any way affect science objectives, including system trade decisions, budget decisions, schedule decisions, etc. He/she reviews the implementation of the project to ensure that the total system is consistent with the overall scientific objectives. He/she provides leadership in assuring that the scientific data are effectively used and the scientific results of the mission are produced expeditiously. The Project Scientist evaluates all scientific requirements placed on the project and provides scientific guidance to the Project Manager and others involved in the program. The Project Scientist is responsible for preparing the Project Science Plan that delineates the scientific portion to the project including instruments, data products, scientific investigation, and interface with the science community.

The Project Scientist further ensures that feedback is provided to the NASA Program Office through official channels of GSFC with assessment of mission success as set forth in the Project Plan.

5.2.8 Project Support Manager

The Project Support Manager is a member of the business support team reporting to the DPM/R. He/she is responsible for scheduling, configuration management, manpower analysis, property management and control, and other general administrative and overall Project planning activities.

5.2.9 Project Financial Manager

The Project Financial Manager is a member of the business support team and reports to the DPM/R. He is responsible for the application of sound financial management principles in the areas of cost control, performance measurement, financial analysis, budget preparation and execution, and pricing.

5.2.10 Project Procurement Manager

The Project Procurement Manager, from the Management Operations Directorate, is responsible for all procurement functions of the Project, including planning, directing, coordinating, and evaluating all Project procurement activities in accordance with NASA authoritative guidelines, and for coordinating these activities with the DPM/R.

5.2.11 Systems Assurance Manager

The Systems Assurance Manager (SAM), from the Office of Systems Safety and Mission Assurance (OSSMA), is responsible for coordination of and follow-up on all the flight assurance disciplines for the project to ensure that the flight elements will meet intended performance objectives. These disciplines include reliability, design review, quality assurance, system safety, and testing.

5.3 RESIDENT OFFICES

Resident offices will be established at HSC and ITT to assist in the management of those activities. The resident offices will consist of a manager, clerical support, engineering support, and a quality engineer.

5.4 NOAA LIAISON OFFICE ACTIVITY

The NOAA Technical Liaison Office at GSFC consists of a small resident staff to serve as the principle interface with the GOES Project on a day-to-day basis. They report directly to the NOAA GOES Systems Acquisition Manager. The NOAA Acquisition Manager works closely with the NOAA GOES Program Manager on all technical and budget issues. The Acquisition Manager is the primary point of contact between NASA and NOAA and is the only individual authorized to provide direction to NASA.

5.5 CONFIGURATION CONTROL BOARD

A Configuration Management plan for the GOES-NO/PQ project has been developed and is documented in S-415-CM-01. This plan requires that all changes be reviewed in a systematic manner to determine their validity and impact on performance, schedule and cost. It ensures that all affected parties are cognizant of the change and have a voice in the decision making process.

The Program Manager chairs the Configuration Control Board (CCB) and has authority to approve any change which does not affect the level I requirements or the interface to the NOAA operated ground system. Members of the NOAA System Acquisition Office who are co-located with the Project represent NOAA on the board. Class I changes require approval from NOAA prior to implementation. The NOAA members of the board are responsible for coordinating the review of the proposed change within the NOAA management structure.

6.0 TECHNICAL SUMMARY

6.1 SPACECRAFT DESCRIPTION

6.1.1 System Description

The GOES-NO/PQ satellites are the new series of satellites that will provide continuity of services that are presently being provided by the GOES-I/M satellites. This series of spacecraft improve on the current series through:

a) The use of Star Trackers improve spacecraft pointing knowledge and stability
b) The change in the WEFAX data transmission service from an analog format to a digital format
c) The addition of the Emergency Managers Weather Information Network (EMWIN)
d) The elimination of the Solar Sail and boom to allow colder detector temperatures to improve performance

The major NOAA facilities that will be used to support the GOES-NO/PQ Program are the Satellite Operations Control Center (SOCC) at Suitland, Maryland; the Command and Data Acquisition (CDA) Station at Wallops, Virginia; and the Space Environment Center (SEC) at Boulder, Colorado.

The payloads on the GOES-NO/PQ satellites consist of: 1) The five channel Imager Instrument, 2) The 19 channel Sounder Instrument, 3) The Space Environment Monitor (SEM) Instruments and 4) The various communications data product services. The major parts of the satellite that will permit the performance of these functions are the main body, the solar array yoke assembly and the solar array. The SXI will be integrated with two of the GOES satellites as an additional payload instrument.

The main body of the satellite contains the propulsion and electronic components and also provides a stable platform on which the Imager and Sounder instruments are mounted. All communications antennas, with the exception of the telemetry and command antennas are hard-mounted on the earth-facing panel for unobstructed earth coverage and maximum alignment stability. The omni antennas are located on the nadir (+Z) and the zenith (-Z) sides of the satellite to provide nearly 4-pi steradian coverage for telemetry and command functions. An unobstructed view of cold space is provided for the Imager and Sounder passive radiation coolers along the +Y pitch axis of the satellite for best performance. A stable magnetic field at the magnetometer sensor location is ensured by the use of an 8.5-meter boom. The magnetometer boom is tied directly to the stable main body structure to minimize any dynamic interaction with the instruments that are located on the optical bench.

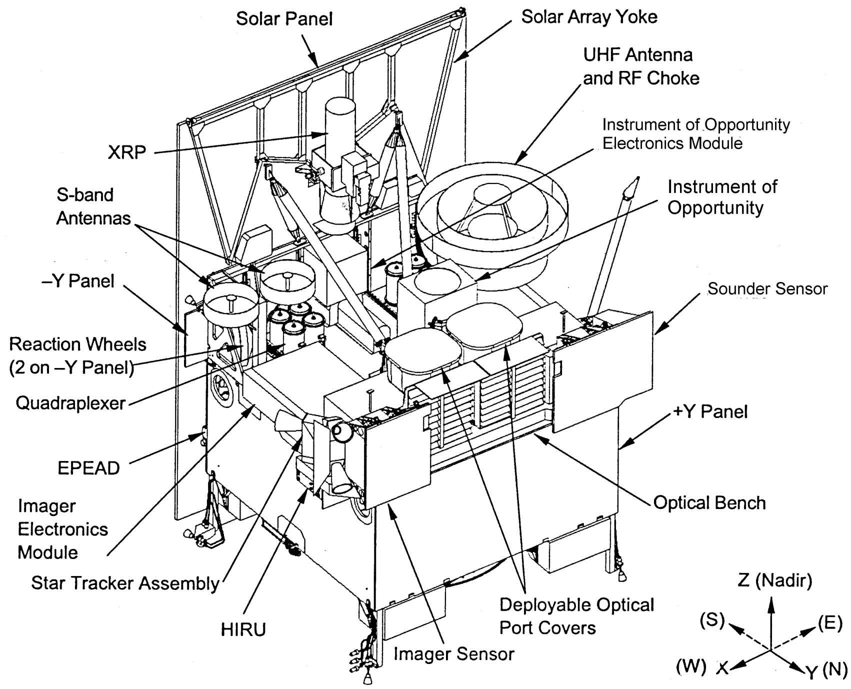
The solar array yoke assembly consists of the yoke frame, yoke equipment panel, Instrument Mounting Panel (IMP), and the X-Ray Positioner (XRP) frame. The Solar X-Ray Imager (SXI), X-Ray Sensor (XRS) and the Extreme UV Sensor (EUV) are mounted on a North-South gimbaled platform that is attached to the yoke assembly. The yoke will continuously rotate about the spacecraft pitch axis to track the sun.

The solar array panel is populated with dual-junction gallium arsenide solar cells and is optimized to provide ample power while stowed for the spinning transfer orbit and when deployed in the on-orbit configuration. The NiH2 battery capacity is sized to permit satellite operations through the eclipse periods.

The dry mass of the satellite is 1226.4 kg and the combined propellant mass and mass margin is 2053.6 kg. The satellite separation mass from the Delta III launch vehicle is 3280 kg.

The spacecraft in its stowed configuration is illustrated in Figure 6.1.1-1.

The GOES spacecraft will be launched from Launch Complex 17B at the Cape Canaveral Air Station using a Delta III launch vehicle.



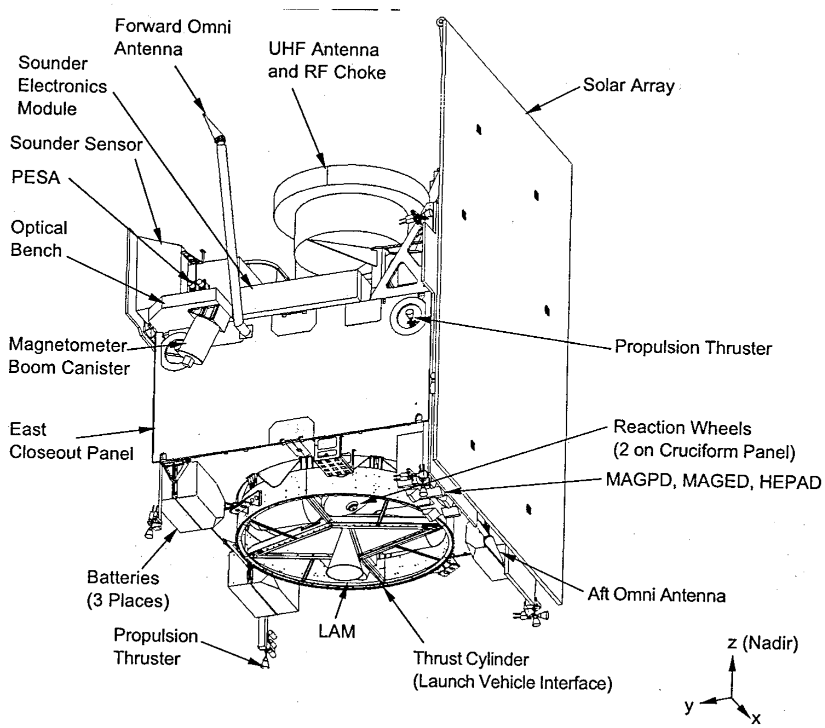


Figure 6.1.1-1 Spacecraft in Stowed Configuration

6.1.2 Structure And Mechanisms Subsystem

6.1.2.1 Structure

The main structure assemblies consist of the payload module and the bus module. The payload module structure supports the communications equipment, the antenna hardware(except for the aft omni antenna), the solar array, yoke and the optical bench. The bus module structure consists of the propulsion subsystem support hardware, the bus panel and the thrust cylinder. These structural assemblies are built-up together, with a bolted interface between them. Once the structure is complete, the assemblies are de-mated for parallel integration.

The yoke frame structure consists of 1.5-inch X 1.5-inch graphite tubes bonded with gussets, and the equipment panel is a 1.5-inch thick aluminum honeycomb core with graphite face-sheets.

6.1.2.2 Mechanisms

The spacecraft mechanisms include the Solar Array Drive (SAD) with an attached Electrical Contact Ring Assembly (ECRA), deployable magnetometer boom, the XRP gimbal assembly, Liquid Apogee Motor (LAM) thermal shield and the deployable optical port covers for the Imager and Sounder optical ports.

6.1.3 Power Subsystem

The electrical power subsystem (EPS) generates, stores, conditions, controls, and distributes the electrical power required for all mission modes for the GOES-NO/PQ spacecraft. It consists of a solar array, battery, integrated power controller (IPC), bus power distribution unit (BPDU), instrument power distribution unit (IPDU), and load switch unit.

The solar array stores energy and generates electrical power when illuminated by the sun. The solar array is a deployable single wing panel, which is populated with dual junction gallium arsenide solar cells. It is comprised of 109 solar circuits. The solar array’s major function is to provide spacecraft power, instrument power, and battery charge power when exposed to the sun.

The GOES-NO/PQ battery supplies spacecraft power and instrument power during eclipse mission modes. The battery consists of twenty-four 123 Ahr nickel-hydrogen independent pressure vessel (IPV) cells. The cells are connected in series and arranged as three 8-cell packs to optimize the dynamic balance of the spacecraft.

The IPC performs the power conditioning, battery charge control, and battery discharge control functions for the spacecraft. It consists of several modules stacked together. There are five bus voltage controller (BVC) modules which condition and regulate the solar array and battery voltages to provide a +53 V primary bus. Two battery charge controllers provide the battery charge control function. The +42 V and +30 V secondary bus voltages are provided through two +42 V low voltage converter (LVC) modules and one +30 LVC module. A master module utilizes a central control amplifier (CCA) to produce a common control signal for the operation of the bus voltage controllers and battery charge controllers. Besides containing the CCA, the master module houses the bus bars, telemetry and command interfaces, and current and voltage sensors.

Power distribution to the instruments and spacecraft subsystems is accomplished through the power distribution units (PDU’s). The bus power distribution unit (BPDU) distributes +30 V and +53 V fused power. It also senses heater current and bus load current and provides on/off switching capability for heater loads. The instrument power distribution unit distributes +30 V, +42 V, and +53 V fused power. It also senses heater current and bus load current and provides on/off switching capability of heaters.

The load switch unit provides latching mechanical relays for on/off switching capability for various loads of the GFE instruments.

6.1.4 Telemetry And Command (T&C) Subsystem

The T&C subsystem is partitioned into a RF group and a digital electronics group.

The RF group consists of the dual omni antennas and the transponders.

The digital group consists of the Central Telemetry and Command Units (CTCU), Remote Telemetry and Command Units (RTCU), and squib driver unit (SDU).

The CTCU decrypts and decodes the up-linked ground commands and multiplexes and formats the downlink telemetry into two simultaneous downlinked data streams: one for the DSN link, and one for the CDA link.

The Multiuse-Data Link (MDL) data multiplexer within the CTCU multiplexes and formats the required data for transmission via the MDL link. The CTCU distributes spacecraft commands and gathers telemetry from the RTCUs via the bi-directional 1553 T&C data-bus

The squib driver unit (SDU) provides electrical power for the pyrotechnic release devices.

6.1.5 Communications Subsystem

The communications subsystem consists of the transponders, antennas and the communications links that are provided on the GOES satellites to provide the data services that are summarized below.

a) Raw Imager and Sounder Sensor Data Link
The raw Imager and Sounder Sensor data is transmitted to the CDA station by the spacecraft. The data is processed at the CDA station by the SSGS equipment.

b) Processed Data Relay Link
The PDR link is used exclusively for relaying processed imaging and sounding data. Once the raw imaging and sounding data have been earth-located and calibrated by the SSGS, they are up-linked to the GOES satellites from the Wallops ground station and then relayed by the satellite to the data user community.

c) Search and Rescue
The SAR signals from the distress beacons are transmitted to the satellite in the frequency band from 406 mHz to 406.1 mHz. The signals are received by the satellite UHF antenna and are then amplified by a low noise amplifier. The output from the SAR receiver is provided to the SAR transmitter, where the signal is up-converted, amplified to approximately 4 watts, then transmitted by the satellite to the ground station where the alert signals are decoded and sent to the Mission Control Center.

d) Data Collection System

Over 12,000 Data Collection Platforms (DCP), in the form of buoys and remote environmental monitoring stations, provide near real-time acquisition and relay of environmental data for centralized distribution and processing. The information is used to provide data to develop analysis, warnings, and forecasts of environmental events such as tsunamis, tropical cyclones, floods, river stage, soil condition, and snow depth.

The satellite DCS receives the incoming signal (e.g., relative frequency, time of occurrence and environmental data) then retransmits these data to the ground for processing. Conversely, the DCS can relay an interrogation signal from the ground station to a special class of the DCPs to turn the platform on at specific times. However, most present-day platforms are self-timed.

e) Weather Facsimile Service
The Wallops ground station re-transmits images and meteorological analysis to the user community through the WEFAX service. Data originates from the National Weather Service and NOAA image processing facilities and are provided for users appropriately configured with ground receiving stations.

f) Multi-Use Data Link
The Multi-use Data Link (MDL) transmission channel shall multiplex the Imager servo error, Sounder servo error, SXI data, Imager ADS, SXI ADS, and the normal telemetry stream.

g) Emergency Managers Weather Information Network
The Emergency Managers Weather Information Network (EMWIN) service transmits over 50,000 pages of text, images, and graphics per day. There are over 10,000 users in 35 countries that are being supported by EMWIN after going into service in June 1996. The service does not require telephone lines and is capable of transmitting data continuously that is simple, reliable and affordable. The information that the EMWIN service provides includes priority weather information concerning tornadoes and hurricanes, floods, severe weather and other information.

6.1.6 Propulsion Subsystem

The Propulsion Subsystem is shown in Figure 6.1.6-1. This is a fully redundant liquid bi-propellant system that is used for both orbit transfer and on-orbit operations.

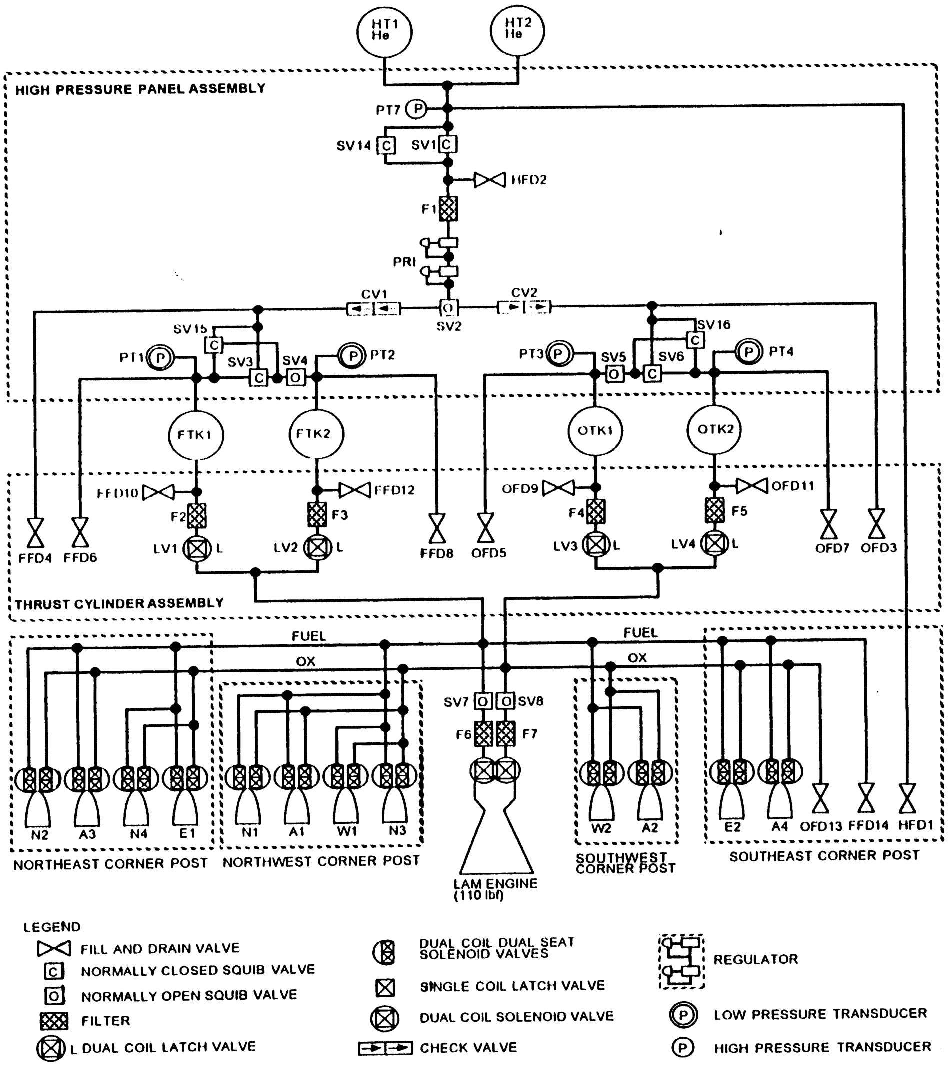


Figure 6.1.6-1 Propulsion Subsystem Block Diagram

Two 12.5 inch diameter by 25 inch long cylindrical pressurant tanks, (graphite/epoxy composite overwrapped pressure vessels (COPVs) with aluminum liners of 6061-T6 alloy), supply helium for propellant tank pressurization during Liquid Apogee Motor (LAM) firings. After completion of the orbit transfer maneuvers, the pressurant tanks are permanently isolated and the propellant tanks operate in a blowdown mode for the remainder of the mission.

Four 35 inch diameter spherical 6Al-4V titanium propellant tanks contain the nitrogen tetroxide (N_2O4) and monomethyl-hydrazine (MMH). These tanks are loaded with 1,656 kg (3,651 lb) of propellant (97% of their capacity) and pressurized at 240 psia for launch. Each propellant tank contains a stacked etched disc propellant management device (PMD) that provides gas free propellant for all propulsion maneuvers with an expulsion efficiency of 99.7%.

One 490-N (110 lbf) LAM provides the impulse for orbit raising to geo-stationary orbits (3 apogee burns & 4 perigee burns). Twelve 9-N (2 lbf) low thrust thrusters (LTT) provide a redundant capability for spacecraft spin up/spin down, reorientation, N-S maneuvers, E-W maneuvers, attitude hold, momentum management, station change and deorbit.

The High Pressure Panel Assembly consists of the following:

a) One high-pressure (0 to 5000 psia) transducer (PT7) monitors the helium tank pressure
b) Two parallel redundant, normally closed, squib valves (SV1 & SV14) isolate the pressurant tanks from the propellant tanks during ground processing and launch
c) One fill & drain valve (HFD2) allows testing of the regulator
d) One 10 micron etched disc pneumatic filter (F1) protects the regulators from particulate contamination
e) Two series redundant pressure regulators reduce the approximate 4200 psia helium to 260 psia for propellant tank pressurization
f) Four low pressure (0 to 400 psia) transducers (PT1, PT2, PT3 & PT4) monitor the pressure in the propellant tanks
g) Four normally-closed squib valves (SV3, SV5, SV15 & SV16) isolate the fuel tanks from the oxidizer tanks during ground processing and launch
h) Two series redundant check valves (CV1 & CV2) prevent vapor migration between the fuel tanks and oxidizer tanks during the orbit raising maneuvers
i) Three normally-open squib valves (SV2, SV3 & SV5) permanently isolate the helium tanks, fuel tanks and oxidizer tanks after geo-stationary orbit is achieved

The Thrust Cylinder Assembly consists of the following:

a) Four 20 micron etched disc propellant filters (F2, F3, F4 & F5) protect downstream latch valves and thruster valves from particulate contamination
b) Four fill & drain valves (FFD10, FFD12, OFD9 & OFD 11) provide a means to load the fuel (MMH) and the oxidizer (N_2O_4) in the propellant tanks
c) Four fill & drain valves (FFD6, FFD8, OFD5 & OFD7) provide a means to pressurize the propellant tanks for launch
d) Two fill & drain valves (FFD4 & OFD3) provide a means to test the regulator
e) Four latch valves (LV1, LV2, LV3 & LV4) provide a means to isolate the propellant tanks from the thrusters

The twelve LTT thrusters are located on the four corner posts (NE, NW, SE & SW) of the spacecraft. In addition, three fill & drain valves (HFD1, OFD13, & OFD14) are located on the SE corner post. HFD1 is used to pressurize the Helium pressurant tank. OFD13 and FFD14 are used to conduct leak and functional tests on the thrusters.

The LAM is located in the center of the axial (Zenith) spacecraft face. Two normally open squib valves (SV7 & SV8) provide a means to permanently isolate the LAM after geo-stationary orbit is achieved. Two 25-micron secondary propellant filters (F6 & F7) provide additional particulate contamination protection for the LAM single seat valves.

6.1.7 Thermal Subsystem

Thermal regulation of the spacecraft is accomplished through a combination of heat pipes, multi-layer insulation, radiators, and automatic heater control. The heat pipes for the GOES spacecraft are flight proven and are manufactured by HSC or Swales Aerospace from an aluminum extrusion with ammonia as the working fluid. All of the heaters are software controlled allowing ground commands to reconfigure the heater set points to optimize component thermal environments over the entire mission.

An optical bench will help to eliminate the effects of spacecraft thermal distortion on the Imager and Sounder instruments and the attitude control sensors. The optical bench design includes kinematic mounts for attachment to the spacecraft and flexure mounts for attachment of the instruments to the optical bench.

Low absorptance thermal control mirrors are silvered ceria-doped micro-sheet with an indium tin oxide (ITO) outer layer to prevent ESD. The mirrors are grounded to the structure with a conductive carbon-loaded bonding material.

The -Y side of the spacecraft is the primary radiator surface. When the spacecraft is on-orbit, heat from the internal units is transferred to this radiator by radiation, conduction, and the heat pipes. The system of heat pipes, multi-layer insulation (MLI), radiators, and commandable heaters provide completely autonomous thermal control system (TCS) operation. All heater circuits and heat pipes are fully redundant; no component will exceed its operational temperature limit should any one heater or any heat pipe fail.

The Imager and Sounder sensor optical ports will be covered during launch and transfer orbit. The covers provide protection from particulate contamination during launch, and reduce instrument heat loss during the transfer orbit. The cover release device is mechanically and electrically redundant.

During the transfer orbit, the solar array covers the main radiator restricting heat rejection to maintain the un-powered units within their survival limits while minimizing heater power requirements.

All of the thermostatic heaters are software controlled through the ACE allowing ground commands to reconfigure heater set points to optimize component thermal environments over the entire mission.

6.1.8 Attitude Control Subsystem (ACS)

The Attitude Control Subsystem (ACS) includes a zero momentum, stellar inertial control system with the attitude sensors located next to the Imager and Sounder on a thermally stable optical bench.

The ACS architecture consists of both transfer orbit and on-orbit attitude sensors and actuators, which are centrally coordinated by the Attitude Control Electronics (ACE). The ACE contains the dedicated on-board third-generation MIL-STD-1750A microprocessor.

Primary software functions include attitude control, thruster operation, and solar array stepping. Additionally, the ACE autonomously handles routine spacecraft maintenance such as battery charge management, heater control, momentum management, and fault detection and correction.

On-orbit attitude control is achieved by operating four Honeywell reaction wheels operated in a zero-momentum configuration that have 4 for 3 redundancy, Ball Aerospace star trackers that have 3 for 2 redundancy, and an internally redundant Litton Hemispherical Inertial Reference Unit (HIRU) for attitude determination. Slit-type sun sensors and piezoelectric earth sensors provide attitude references for the spin mode during transfer orbit operations. Accelerometers measure thruster impulse during on-orbit maneuvers for support of accurate image motion compensation (IMC) uploads. The ACE supports an analog and digital interface to the Imager and Sounder which supplies mirror steering and dynamic motion compensation signals. Thrusters and tank latch valves are operated directly by the ACE in support of maneuvers and momentum management.

The system includes an on-board safehold mode which is designed to autonomously keep the spacecraft and payload in a safe condition in the event of an anomaly. This system can be overridden by ground command.

6.1.9 Image Navigation and Registration (INR)

The INR system on the GOES-NO/PQ satellites provides improved performance with respect to the GOES-I/M satellites by providing a more stable, accurate base for instrument pointing. Pointing drifts are controlled by co-locating the Imager and Sounder Instruments with the star trackers and gyros on a thermally stable optical bench that is kinematically mounted to the spacecraft to de-couple it from spacecraft thermal distortions. The stellar inertial system provides a precise attitude reference that is inherently insensitive to diurnal and seasonal events. The optical bench maintains co-alignment of the instruments and the attitude sensors. The low-pointing drift achieved is crucial to registering successive image frames and will enable accurate navigation with minimum use of short span attitude adjustments (SSAAs). The stellar inertial system, combined with on-board delta-velocity measurement capability, also provides rapid recovery from attitude transients following maneuvers.

The major components of the INR system are the Imager and Sounder Instruments, the satellite ACS and the ground based SSGS.

6.1.10 Dynamic Interaction Measurement Subsystem

Special purpose hardware consisting of Angular Displacement Sensors (ADS) on the satellite will permit the measurement of dynamic interaction between moving mechanisms on the spacecraft. The ADS data from locations near the Imager and SXI Instruments will be transmitted from the satellite on the MDL link. The Imager/Sounder servo error data will also be provided on the MDL link for use as a diagnostic tool.

6.1.11 Space Environment Monitoring System

The SEM system consists of a set of instruments designed to provide monitoring of the *in situ* magnetic field and charged particle environment at synchronous orbit as well as real-time remote sensing of solar activity at X-ray and extreme ultraviolet wavelengths. The SEM instrument complement includes a three-axis vector magnetometer, a suite of energetic particle detectors, and a whole (solar) disc X-ray and EUV radiation monitor. These are all provided by the prime spacecraft contractor as contractor furnished equipment (CFE). In addition, a Solar X-ray Imager (SXI) is provided as Government furnished equipment (GFE) to be accommodated by the spacecraft. The SXI will provide images of the sun in one of several X-ray spectral bands, selectable by ground command.

6.1.11.1 Vector Magnetometer

The triaxial fluxgate magnetometer measures three orthogonal components of the varying ambient magnetic field with an accuracy of ± 1 nanoTesla (nT). Redundant instruments are accommodated on a deployable magnetometer boom 8.5 meters long to minimize interference from spacecraft fields. The prime magnetometer is mounted at the tip of the boom, with the redundant magnetometer one-meter inboard. The analog signal from each axis is processed through a fifth order 0.5 Hz cutoff anti-aliasing filter and sampled at a rate of 1.95 sec^{-1} through a high-resolution A/D converter internal to the instrument. The spacecraft design provides for simultaneous operation of both magnetometers to facilitate on-orbit test and calibration of spacecraft magnetic fields.

6.1.11.2 X-ray and Extreme Ultraviolet Sensor (XRS/EUV)

The XRS provides real-time measurements of total disc solar x-ray emissions in two channels covering the spectral ranges of 0.05 to .4 Angstroms (shortwave) and 0.1 to 0.8 Angstroms (longwave). A dual ion chamber mounted in a collimator/telescope designed to reject out-of-field signals and interfering particle flux accomplishes detection of X-ray flux. A sweeper magnet is provided to further reduce the effect of ambient electrons by deflecting those with energy below approximately 4 MeV. The XRS is sensitive to X-ray flux as small as 5 x 10^{-9} watts/m^2 in the shortwave channel and 2 x 10^{-8} watts/m^2 in the longwave channel, with a dynamic range of 10^5 in both channels.

The EUV sensor provides real-time measurements of total disc solar emissions in 5 spectral bands EUV-A through EUV-E. Transmission gratings, filters, and solid state detectors are used to measure the flux in bands A through D (8-17, 17-40, 40-65, and 65-100 nm). Lyman alpha filters and a solid state detector are used to measure the flux in EUV-E (119-124 nm). The specified threshold flux is 1 x 10^{-6} watts/m^2/nm in EUV-A, -C, and –E and 2 x 10^{-6} watts/m^2/nm in EUV-B and –D. Specified dynamic range is 10^3 in EUV-A and –B and 10^2 in EUV-C, -D, and –E.

The XRS and EUV sensor heads are supported by a common Data Processor Unit (DPU) which is designed to meet the specified requirement for a monotonically increasing output in each XRS/EUV channel as a function of input flux. The combined assembly is mounted and co-aligned with the SXI and the Precision Sun Sensor on the N-S tracking X-ray Positioner (XRP) which in turn is mounted to the E-W tracking solar array yoke, thereby comprising a solar-pointing platform which ensures that the solar disc is always contained fully in the field-of-view of the instruments.

6.1.11.3 Energetic Particles Sensor and HEPAD (EPS/HEPAD)

6.1.11.3.1 Magnetospheric Electron and Proton Detectors

The EPS/HEPAD suite of sensors has been expanded effective with GOES-N/Q to provide improved spatial and spectral coverage relative to the earlier GOES systems. Spectrally, magnetospheric protons with energy between 80 and 800 KeV and electrons with energy between 30 and 600 KeV have been added to the former coverage of electrons > 0.8 MeV and electrons > 0.6 MeV. The new detectors, which provide the increased coverage, are the Magnetospheric Proton Detector (MAGPD) and the Magnetospheric Electron Detector (MAGED). These detector arrays, consisting of nine telescopes each, are close derivatives of the TIROS SEM-2 Medium Energy Proton and Electron Detector (MEPED) telescopes. The acceptance aperture for both species is limited to about 30 full angle (about 0.2 sr) by a collimator and a dual solid state detector telescope. Coincidence logic and threshold discriminators provide spectral resolution for both species in 5 logarithmically spaced energy bands. For the MAGPD, a sweeper magnet excludes electrons less than a few hundred KeV in energy. Corresponding protection for the MAGED against proton contamination is not provided, so ground correction is required. The nine telescopes for each detector array provide spatial resolution in 5 fields-of-view fanned over >170 end-to-end in the equatorial plane and 5 fields-of-view likewise fanned over >170 in the meridian plane. The two fans share the central FOV.

6.1.11.3.2 Energetic Proton, Electron and Alpha Detector (EPEAD)

The EPEAD detectors are identical to the EPS dome and telescope provided on the GOES-I/M spacecraft. Spatial coverage is improved by providing these detectors in two opposing fields-of-view directed east and west in the equatorial plane. EPEAD #1 and EPEAD #2 provide multiple measurements characterizing the charged particle population. Protons are monitored in 7 logarithmically spaced bands for energies between 0.8 MeV and >500 MeV. Alpha particles with energies between 3.8 and 400 MeV are monitored in 6 logarithmically spaced bins. Electrons are measured in 3 integral bands provided by the dome detectors, with E>0.6 MeV, E>2.0 MeV, and E>4.0 MeV, respectively.

6.1.11.3.3 High Energy Proton and Alpha Detector (HEPAD)

The HEPAD extends the energy range measured to protons of energy greater than 330 MeV by adding three differential bands between 330 and 700 MeV and one integral band for energy greater than 700 MeV. The single, zenith directed, acceptance aperture has half-angle of 30 and geometric factor of 0.9 cm^2sr. The three-element HEPAD telescope has two solid state detectors in front of a Cerenkov radiator faceplate on a photomultiplier tube (PMT). Triple coincidence of signals from all three elements identifies an in-aperture event, and pulse height analysis of the PMT signal identifies the proper particle/energy bin. The HEPAD telescope is identical to that on GOES-I/M. The signal analysis electronics is modified because of parts obsolescence and to standardize the interface to the Data Processing Unit.

6.1.11.3.4 Data Processing Unit (DPU)

The DPU is a new microcontroller based design which provides control and signal interfaces, detector bias power, and unregulated low-voltage power to the two EPEADs, MAGPD, MAGED and the HEPAD. It provides the sole EPS/HEPAD interface to the spacecraft. All housekeeping data for the system is sampled and digitized to 8-bit accuracy within the instrument. Sensor temperature monitors pass through the DPU to the spacecraft, where they can be monitored with the instrument power off. While most of the Space Environment Monitor hardware has always been single-string design, the GOES-NO/PQ EPS/HEPAD DPU design is fully redundant.

6.1.12 Solar X-Ray Imager (SXI)

The SXI instrument is a follow on to the SXI instrument developed by the Marshall Space Flight Center for flight on GOES-M. For GOES-NO/PQ, the SXI instrument will be a new design developed and manufactured by Lockheed Martin Advanced Technology Center under Contract NAS5-97181, and will be provided to the Spacecraft Contractor. All four spacecraft will be built to accommodate an SXI instrument, however NOAA only has plans to fly SXI on two of the missions.

The objective of the SXI is to map solar corona activity in regions extending above the solar disk in the soft X-Ray region of the electromagnetic spectrum from 0.6 to 6 nm. These observations will enable space weather forecasters to monitor solar features such as flares, loops, coronal holes and coronal mass ejections on the solar disk and to a limited extent over the limb. Knowledge of the location and magnitude of such activity on the surface of the sun greatly improves the forecaster’s ability to predict which solar phenomena are likely to result in terrestrial effects. The possible terrestrial effects include radiation damage to operating spacecraft and radiation hazard to astronauts, perturbation of satellite orbits due to atmospheric heating by short wave radiation, disruption of power distribution grids, damage to electric company equipment, disruption of various kinds of communications, and interference with navigation equipment.

The SXI uses a Harvey-Thompson #17 telescope, two tandem six position filter wheels, and an X-Ray sensitive 512 x 580 pixel Charge Coupled Device (CCD) array to produce an image of the sun in one of a set of ground commandable bandwidths. The instrument can also be programmed to autonomously execute a prescribed observing sequence with controlled filter selection and exposure settings. The nominally square pixel IGFOV is 5x5 arc. sec., yielding a full frame field-of-regard of 42x48 arc minute. The SXI incorporates a two dimensional High Accuracy Sun Sensor (HASS) co-aligned with the CCD monitoring the sun's position in the two dimensions, with quantization level of 1.67 arc sec. The 48 arc minute dimension of the CCD will be oriented east to west in orbit, enabling one dimensional image stabilization by time-delay-integration.

The spacecraft contractor will co-align the SXI with the XRS and a controlling Precision Sun Sensor on a single axis X-Ray Positioner (XRP), with the long dimension of the CCD array parallel to the rotation axis. The XRP is in turn mounted to the yoke of the solar array, which rotates by stepper motor drive to track the sun. The resulting two axis solar pointing platform ensures that the whole solar disc is contained in the SXI field-of-regard at all times. The prescribed orientation of the CCD array enables image motion compensation of the torsional pointing disturbances which may occur in response to stepper motor excitation.

6.1.13 Imaging Instrument Subsystem

The Imager Instrument is a five-channel instrument designed to sense radiant and solar reflected energy from sampled areas of the earth. It is being developed by ITT/SCD under contract NAS5-96090 and will be provided as GFE to the spacecraft contractor.

The Imager's multi-element spectral channels simultaneously sweep an 8 km North-South (N-S) swath along an East-West (E-W) path by means of a two-axis gimbaled mirror scan system. The position and size of a selected area are controlled by command. The instrument is capable of producing full-earth discs images, sector images that contain the edges of the earth and various sizes of area scans completely enclosed within the earth scene. Area scan selection permits rapid continuous viewing of local areas for monitoring of mesoscale phenomena and accurate wind determination.

The Imager is also used to provide a star sensing capability. The time and location of a star is predicted very accurately by the SSGS, and translated into the satellite's orbital geometry and instrument field of view. From a set of this data, the SSGS selects a location and time that is convenient within the image scenario. The Imager is then pointed to the selected space location within its 21 degree N-S by 23 degrees E-W star sensing field of view, and the scan motion is stopped. As the star image passes through one or two of the eight elements of the visible channel detector array, it is sampled approximately 7500 times.

An illustration of the image frame size formats and the time required for some typical Imager and Sounder frame formats is shown in Figure 6.1.13-1 and Table 6.1.13-1. The key features of the Imager are summarized in Table 6.1.13-2. The Imager channel characteristics are shown in Table 6.1.13-3

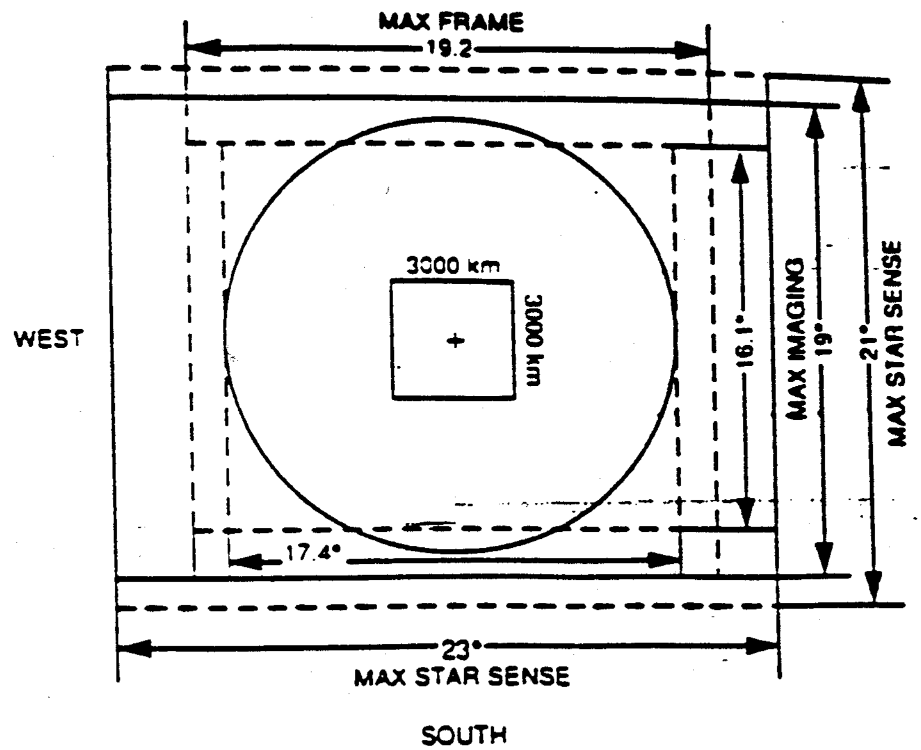


Figure 6.1.13-1 Nominal Imager and Sounder Frame Sizes

Table 6.1.13-1 Nominal Imager Frame Times

Image Size	Imager
Full Earth Image 17.4° x 17.4° (Includes space clamp, star sense, and blackbody calibration events)	26.5 min
3000km N-S by 3000km E-W	3 min
100km N-S by 1000km E-W	40 sec

Table 6.1.13-2 Key Features of the Imager Instrument

General Characteristics	
Optical Aperture	12.25 inches (31.1 cm)
Method of Scan	Two Axis, Line scan frame
Data Quantization	10 bits
Data Rate	2.6208 megabits per sec
Calibration	Space and Blackbody
Design Life	5-years minimum, plus 2-years on-orbit storage
Spatial Resolution	
Visible Channel	28 ìradians
IR Channels 2,4,5	112 ìradians
IR Channel 3	GOES-N 224 ìradians GOES OPQ 112 ìradians
Module Dimensions	
Sensor Module	78.7 x 81.3 x 119.4 cm
Electronics Module	20.3 x 43.1 x 66 cm
Power Supply Module	15.2 x 25.4 x 28 cm
Module Assembly Weight	
Sensor Module	98.2 kg
Electronics Module	37.1 kg
Power Supply Module	7.3 kg
Total Weight.	137.2 kg

Table 6.1.13-3 Imager Channel Requirements

Channel	Channel Half-Amplitude Wavelength and Tolerance (Micrometers) Lower	Upper	Spatial Resolution Half-Amplitude and Tolerance (1) (IGFOV in ìrad)	Max S/N (2)	NEDT rms (max)	Required Range of Measurements	End Use
1	0.52 ±.01	0.71 ±.01	28(4) ±15%	250(3)		0-100%	Cloud Cover
2	3.73 ±.03	4.07 ±.03	112 ±15%		.20K @300K	4-335K	Night Time Clouds
3 SN-08	13.00 ±.07.	13.70 ±.07	224 +5% -15%		.35K @300K	4-320K	Cloud Cover & Height
3 SN 9-11	13.00 ±.07	13.70 ±.07	112 ±15%		.70K @300K	4-320K	Cloud Cover & Height
4	10.2 ±.10	11.20 ±.10	112 ±15%		.20K @ 300K	4-320K	Surface Temp.
5	5.80 ±.10	7.30 ±.10	112 ±15%		.30K @230K	4-320K	Water Vapor

(1) For one and all multiple detectors, including all aberrations and diffraction effects
(2) S/N is the ratio of the mean signal to rms noise. The rms noise is the one sigma variation from the mean of a large number of samples measured viewing a constant radiation source
(3) S/N for the 4th magnitude, BO star shall be at least 3:1
(4) Channel 1 IGFOV is relaxed to 42ìrad for the period within 2 hours of s/c midnight

6.1.14 Sounding Instrument Subsystem

The Sounder instrument is designed to provide data from which atmospheric temperature and moisture profiles, surface and cloud-top temperature and ozone distribution can be deduced by mathematical analysis. The construction of the electronics and power supply modules are similar to the modules that are used in the imaging instrument.

The Sounder’s multi-element detector array assemblies simultaneously sample four separate fields or atmospheric columns. The infrared channel spectral definition is provided by a rotating filter wheel, which brings selected filters into the optical path of the detector array. Spectral separation of the infrared channels is provided in each of three bands consisting of the long-wave (12 to 14.7 m), mid-wave (6.5 to 11 ìm) and short-wave (3.7 to 4.6 ìm). The Sounder channel description is shown in Table 6.1.14-1.

Table 6.1.14-1 Sounder Channel Description

Channel	Central Wavenumber (cm^{-1})	Half-Power Bandwidth (cm^{-1})	1% Absolute Transmission Max BW (cm^{-1})	0.1% Absolute Transmission Max BW (cm^{-1})	Anticipated Max Brightness Temp (k)	NEN ($mW/m^2/sr/cm^{-1}$)	Half Power Centering Tolerance (cm^{-1})
1	680 ±1.8	13 ±3	40	4.5xHBW	260	1.43	±1.5
2	696 ±1.8	13 ±3	40	4.5xHBW	260	1.43	±1.5
3	711 ±1.8	13 ±3	40	4.5xHBW	270	0.69	±1.5
4	733 ±1.8	16 ±3	40	4.5xHBW	290	0.69	±1.5
5	748 ±1.8	16 ±3	40	4.5xHBW	300	0.57	±1.5
6	790 ±3	30 ±4	60	4.5xHBW	315	0.28	±2.0
7	832 ±4	50 ±7	120	4.0xHBW	330	0.23	±3.5
8	907 ±5	50 ±7	150	4.5xHBW	335	0.16	±3.5
9	1030 ±3	25 ±3	70	4.0xHBW	310	0.33	±1.5
10	1345 ±6	55 ±7	160	4.0xHBW	300	0.16	±3.5
11	1425 ±8	80 ±9	240	4.0xHBW	285	0.12	±4.5
12	1535 ±6	60 ±4	150	4.0xHBW	265	0.15	±2.0
13	2188 ±4.4	23 ±3	60	3.6xHBW	310	0.013	±1.5
14	2210 ±3	23 ±3	60	3.6xHBW	295	0.013	±1.5
15	2245 ±4.4	23 ±3	60	3.6xHBW	275	0.013	±1.5
16	2420 ±5	40 ±5	100	3.6xHBW	330	0.0080	±2.5

17	2513 ±5	40 ±5	100	3.6xHBW	335	0.0082	±2.5
18	2671 ±10	100 ±10	300	3.6xHBW	335	0.0036	±5.0
19	14367 ±220	1000 ±150	N/A	N/A	N/A	0.05%A	±75.0

The Sounder visible and star sensor detector arrays are illustrated in Figure 6.1.14-1 and the Sounder filter wheel and IR channel separation concept is illustrated in Figure 6.1.14-2. The rotation of the filter wheel is synchronized with the stepping motion of the scan mirror. An 1120 ìrad swath is sampled by four IGFOVs of 262 ìrad which are spaced on 280 microradian centers and step 280 ìrad in each E-W or W-E motion. As commanded from the ground, the scan system will generate frames of any size or location by stepping W-E, followed by a N-S step of 1120 ìrad, and then stepping in the E-W direction. This pattern is repeated until the desired frame is complete. As indicated in Figure 6.1.14-1, the visible channel detectors are not part of the filter wheel, but are separate sets of uncooled detectors having the same field size and spacing as the IR detectors. These detectors are sampled at the same time as the IR channels in order to provide registration of all sounding data.

The Sounder used in the GOES system provides a star-sensing capability independent from the visible sounding channel detectors, to accurately determine instrument pointing parameters. Time and location of a star are predicted very accurately by the SSGS. From a set of this data, the OGE selects a location and time that is convenient within the sounding scenario. The Sounder line-of-sight is pointed to a predetermined location within its 21 degree N-S by 23 degree E-W star-sensing view and the scan is stopped. As the star image passes through one or two detectors, the signal is sampled four times during each 0.1 second sounding interval. This signal is encoded to a 13 bit resolution and transmitted to the ground for extraction and use by the SSGS at the ground station.

An illustration of the Sounder frame size formats and the time required for some typical sounding formats are indicated in Figure 6.1.13-1 and Table 6.1.14-2.

Table 6.1.14-2 Nominal Sounder Frame Times

Image Size	Sounder
Full Earth Image 16.1^{o} x 16.1^{o} (Includes space clamp, star sense, and blackbody calibration events)	454 min
3000km N-S by 3000km E-W	42 min
100km N-S by 1000km E-W	5.3 min

The key features of the Sounding Instrument Subsystem are summarized in Table 6.1.14-3.

Table 6.1.14-3 Key Features of the Sounder Instrument

General Characteristics	
Optical Aperture	12.25 inches (31.1 cm)
Method of Scan	Two Axis, discrete steps 280 ìr (10 km) E-W 1120 ìr (40 km) N-S
Data Quantization	13 bits
Data Rate	40 kbps
Calibration	Space and 290K Blackbody
Design Life	5-years minimum, plus 2-years on-orbit storage
Spatial Resolution	224 +/- 55 ìr
Module Dimensions	
Sensor Module	78.7 x 81.3 x 149.9 cm
Electronics Module	20.3 x 43.1 x 66 cm
Power Supply Module	15.2 x 22.4 x 28 cm
Module Assembly Weight	
Sensor Module	106.3 kg
Electronics Module	33.9 kg
Power Supply Module	7.7 kg
Total Weight	147.2 kg

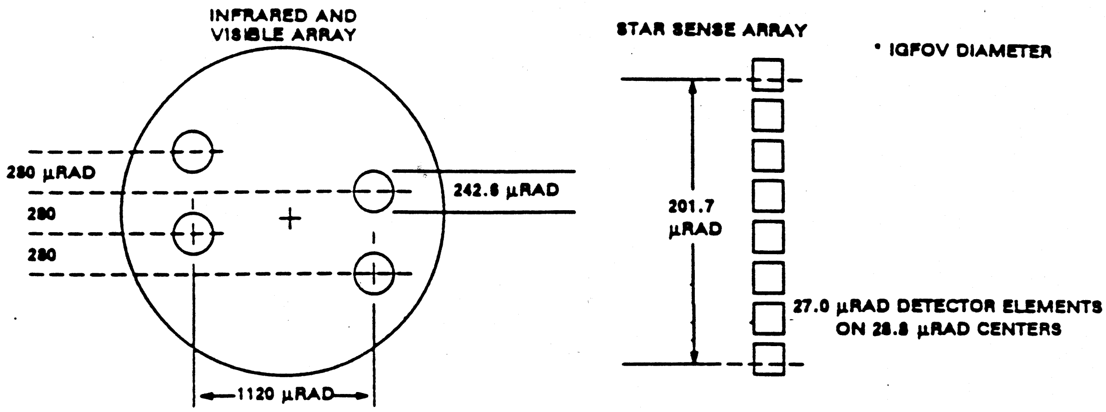


Figure 6.1.14-1 Sounder Visible and Star Sense Detector Arrays

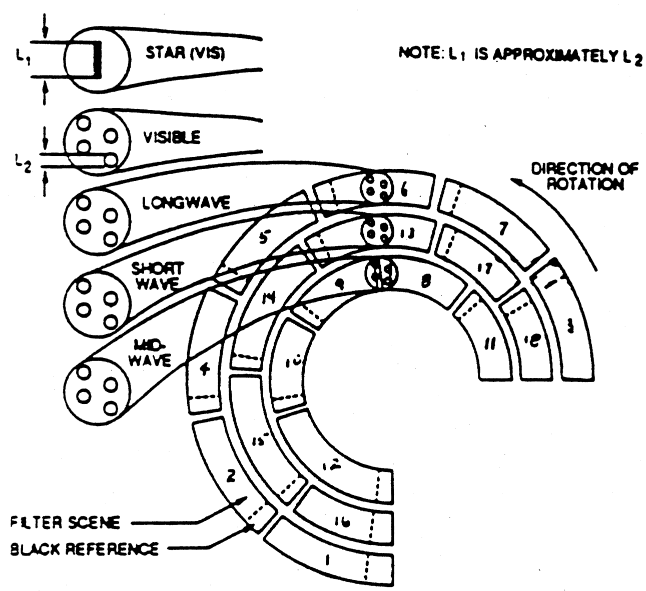


Figure 6.1.14-2 Sounder Filter Wheel and Channel Separation

6.2 SPACECRAFT SUPPORT GROUND SYSTEM (SSGS)

The SSGS architecture will maintain the existing GOES-I/M architecture and interfaces when possible to avoid unnecessary development, utilize proven interfaces and reduce impact to ongoing operations. The baseline SSGS system does not require any modifications to the existing Sensor Processing System (SPS) and Product Monitor (PM) system, or to the GOES Variable (GVAR) data format.

Indicated below is a summary description of the SSGS that will be provided to support the GOES-NO/PQ Program.

a) GOES-NO/PQ Telemetry and Command Transmission System (NTACTS)
b) GOES Telemetry and Command Transmission System
c) Multi-use Data Link (MDL) Receive System
d) New and/or modified Orbit and Attitude Tracking System (OATS) Software

The SSGS will use the Integral Systems Inc. (ISI) EPOCH-2000 commercial-off-the-shelf (COTS) software for instrument subsystem testing and basic mission operations.

6.3 LAUNCH VEHICLE

6.3.1

The Delta III launch vehicle is an evolution from the Delta II launch vehicle. The major elements of the Delta III launch vehicle are Stage I, Stage II, payload fairing, payload attach assembly and the avionics.

Stage I of the Delta III launch vehicle uses the Delta II Rocketdyne RS-27A main engine and a hydraulically gimbaled thrust chamber and nozzle that provides pitch and yaw control. Two vernier engines provide roll control during main-engine burn, and attitude control between main-engine cutoff (MECO) and second stage separation. The Rocketdyne RS-27A main and vernier engines are both unchanged from Delta II. Nine 1168-mm (46 in.) diameter Alliant graphite epoxy motors (GEM LDXL’s) (strap-on solid rocket motors (SSRM’s)) are used to augment the first-stage performance and are a direct evolution from the GEM’s used on Delta II. The liquid oxygen (LO2) tank is a Delta II tank with increased skin thickness. The 4m-diameter fuel tank is a new design.

Stage II of the Delta III uses a single cryogenic Pratt & Whitney RL10B-2 engine developed from the RL10A-4-1 currently used on Centaur. The second-stage propulsion system produces a thrust of 24,750 lb with a total propellant load of 37,090 lb., providing a total burn time of approximately 700 seconds. The Delta III will place the satellite into a super-synchronous transfer orbit with an apogee at 73,000 km. The satellites operation orbit will be achieved via the on-board propulsion system.

The Delta III composite payload fairing (PLF) is 4m in diameter and is a larger version of the 3.05 m Delta II fairing.

The Payload Attach Assembly is a new composite design, built using the same materials and processes as the PLF.

The Delta III avionics are based on the Delta II avionics, upgraded to a redundant single fault tolerant design. The software is modified to accommodate the Delta III Stage II engine and Stage I motor upgrades.

Figures 6.3.1-1 and 6.3.1-2 illustrate the major Delta III components and a typical geosynchronous transfer orbit.

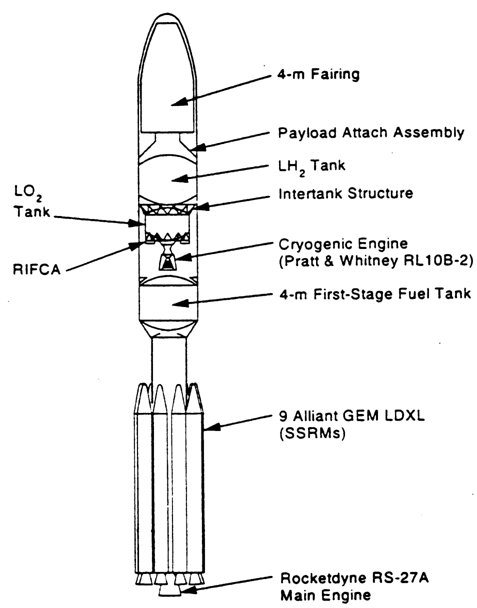


Figure 6.3.1-1 Delta III Launch Vehicle Description

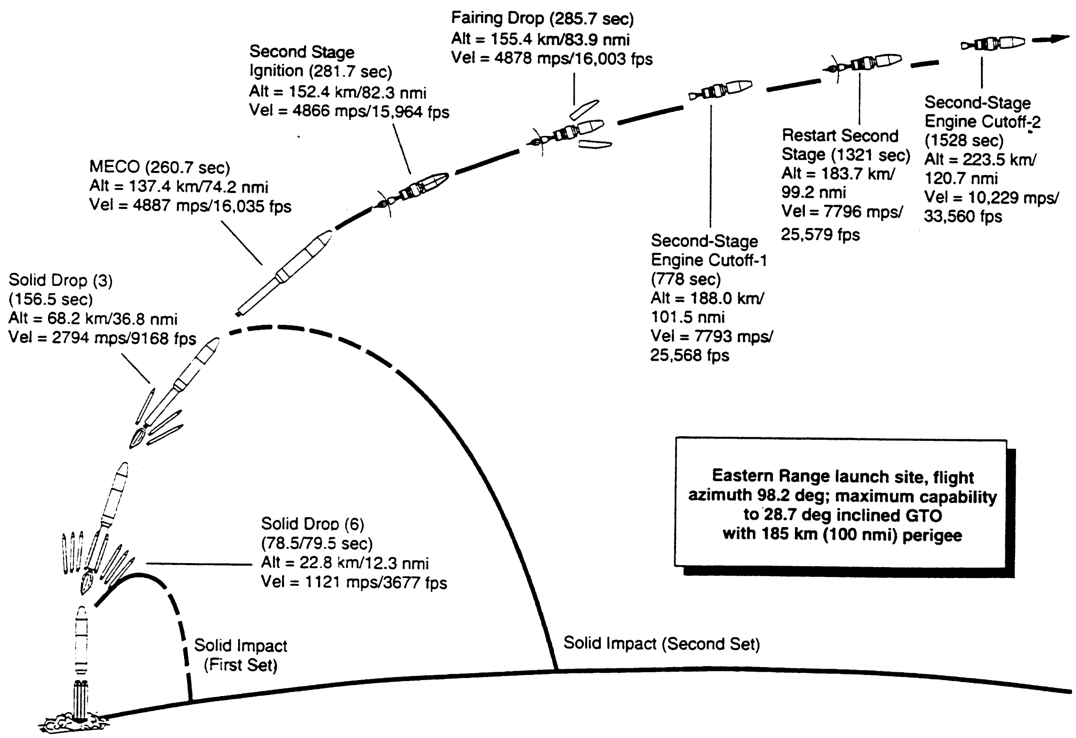


Figure 6.3.1-2 Typical Delta III GTO Mission Profile

6.4 OPERATIONS

6.4.1 Launch and Orbit Raising

The flight operations activity will: 1) Place the spacecraft into geosynchronous orbit at a location assigned for in-orbit testing with sufficient propellants remaining to perform the lifetime mission, and 2) Complete all bus checkout operations and configure the spacecraft for Post Launch Testing (PLT) within 24 days after launch.

The satellite operations control center during the launch of the satellites will be at a Government Operations Center (GOC) facility. The Flight Dynamics System personnel from HSC will be located in the GOC to support the spacecraft launch activity.

6.4.1.1 Launch Operations

The ground support functions summarized below are required for launch and post launch testing.

Table 6.4.1-1 Ground Network Launch Support

Ground Segment	Launch Support	Post Launch Testing
NASCOM	X	X
JPL DSN Network		
Madrid	X	
Canberra	X	
Goldstone	X	
SOCC	X	x

<u>NASA Support Facilities</u>
The NASA Communications Network (NASCOM) will be used to provide voice and communications data circuits during pre-launch, launch, and post-launch activity.

<u>JPL Deep Space Network</u>
The Deep Space Network (DSN) will be used to support the launch of the GOES satellites. HSC will arrange for the DSN support from the Jet Propulsion Laboratory.

The JPL DSN will maintain and operate the DSN tracking network during the launch phase of the mission.

<u>NOAA Support Facilities</u>
The SOCC at NOAA will be used as the focal point during the GOES launch operations activity. The SOCC will be responsible for obtaining necessary satellite data in real time; processing these data for display and for analysis by satellite analysts; satellite command operations; and mission scheduling.

The NESDIS is responsible for implementing, operating, and maintaining the SOCC facility.

6.4.1.2 Orbit Raising

The satellite orbit raising (LOR) activity indicated will begin following satellite separation from the launch vehicle. The flight dynamics system personnel from HSC will be in residence at the Government Operations Center (GOC) during LOR activity that is estimated to be complete within approximately 19 days after launch. The orbit determination activity will use HSC’s FDS software using a DSN interface.

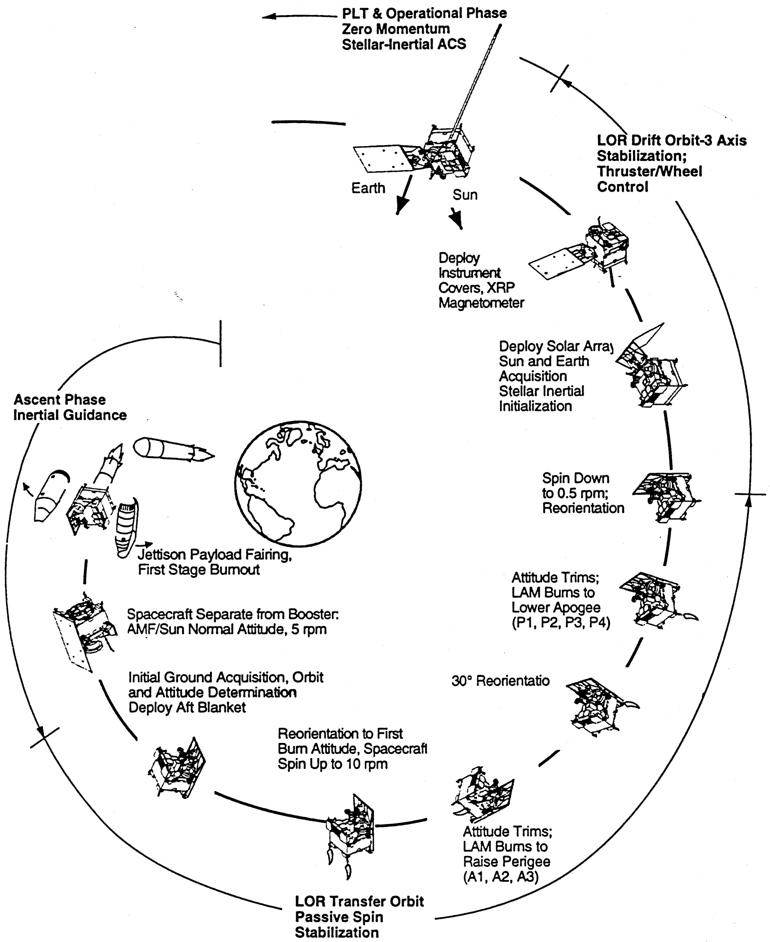


Figure 6.4.1-1 GOES Orbit Raising Sequence

6.4.2 Post-Launch Test

The post launch test will be performed by personnel from GSFC with support from HSC. This support activity will consist of: 1) evaluating the performance of the instruments 2) Completing the system level INR performance evaluation and 3) Validating satellite system level performance. The satellite handover to NOAA will occur following the completion of this activity.

6.4.3 Mission Operations

Mission operations are the responsibility of NOAA. Engineering support from GSFC and HSC will be available to support NOAA on an as needed basis.

7.0 SCHEDULES

As an operational weather satellite system, GOES is an important asset in safeguarding life and property. As such, continuity of service is of prime importance to our customer and the nation.

GOES satellites are designed for 5 year missions. However, NOAA determines the actual satellite replacement schedule based upon the performance of the on-orbit spacecraft. NOAA’s assessment of the schedule is conveyed to NASA twice per year as part of the budget guidelines. They establish requirements for Launch Readiness Dates (LRD) and Planning Launch Dates (PLD). The LRD is the date on which both the spacecraft and launch vehicle must be available to support a launch. The PLD is the most likely date on which NOAA will want the launch to occur. Based on these requirements, NASA revises the contractor’s schedule requirements.

Master schedules which integrate all project activities by mission are maintained in the GOES Program Office. Intermediate and detailed schedules are maintained by the various contractors for their respective activities. These schedules are reported to the GOES Program Office in accordance with the contract CDRL requirement.

The master phasing schedules for the GOES-N/O Satellite are included in Appendix D.

8.0 RESOURCES

NOAA requests budget preparation twice per year due in March and August. NOAA provides program guidance on launch dates (Readiness and Planning), program scope and funding available by fiscal year.

NASA develops funding requirements in response to NOAA's guidance. Funding requirements are reviewed by the Director of Flight Projects and the GSFC Center Director before submission to NOAA. The Program Commitment Agreement, Program Cost Commitment, Program Plan and this Project plan are updated accordingly.

Appendix E contains the budget direction from NOAA, the formal transmission letter from GSFC to NOAA and the budget package reviewed by the GSFC Center Director. This appendix shall be kept up to date with the current requirements. The GSFC Center Directors approval (signature of the transmittal letter) and their formal transmission to NOAA shall constitute authority to replace Appendix E with the current requirements

Once per year, a comprehensive manpower plan is developed. This plan includes both civil service manpower and support service contractors.

9.0 CONTROLS

GOES is a reimbursable program being managed by NASA for NOAA. As such, any change in program scope, performance, funding or schedule must be approved by NOAA. Typically, as part of the semi-annual budget process, NOAA directs changes in the program scope, funding or launch date requirements (both readiness and planning). NASA responds to this direction in the form of a new POP which is reviewed and approved by the Director of GSFC. Following approval of the POP, the Program Plan, PCA and PCC are updated accordingly.

Changes in system performance are controlled by the Project Configuration Management Plan. All changes that affect a level I performance criteria including waivers are systematically reviewed by NASA and NOAA technical personnel. NOAA concurrence with the change is required prior to implementation.

10.0 IMPLEMENTATION APPROACH

The GSFC has been assigned lead center responsibility for the GOES Program. The system is being procured from various major aerospace contractors.

GOES is a reimbursable program funded by NOAA. Funds are transferred by NOAA to GSFC in a timely manner for the various project activities. NOAA earmarks the funds by project activity i.e. spacecraft, Imager/Sounder instruments etc). NASA may reallocate funds between elements with proper notification to NOAA.

11.0 ACQUISITION SUMMARY

11.1 SPACECRAFT

The prime contractor for the GOES-NO/PQ spacecraft contract is the Hughes Space and Communications (HSC) subsidiary of the Hughes Electronics Company. HSC was competitively selected to complete a Firm Fixed Price contract for the fabrication, integration, testing, and launch of the satellites. The contract includes the following deliverables and features:

a) Two spacecraft that are designated as GOES-N and GOES-O
b) Separate fixed price options for two additional spacecraft designated as GOES-P and GOES-Q
c) Spacecraft integration of three government furnished instruments consisting of the Imager, Sounder and Solar X-Ray Imager
d) New or modified spacecraft unique ground support equipment designated as the Spacecraft Support Ground System (SSGS), will be procured as part of the prime spacecraft contract
e) SEM payload instruments consisting of the Magnetometer, X-Ray and Extreme Ultraviolet Sensor (XRS/EUV), Energetic Particles Sensor and HEPAD (EPS/HEPAD), Energetic Proton, Electron and Alpha Detector (EPEAD), and the High Energy Proton and Alpha Detector (HEPAD)
f) All spacecraft delivered on orbit (contractor provided launch services)
g) Pre-priced “Off ramp” to allow the Government to provide the launch services
h) Replacement mission or refund for mission failure in the first year
i) Structured penalties for failure of critical mission services

11.2 IMAGER AND SOUNDER INSTRUMENTS

11.2.1 INSTRUMENT DEVELOPMENT

The prime contractor for the Imager and Sounder Instruments is the ITT/Aerospace Communications Division (ITT/ACD) Corp. in Fort Wayne, In. This was a non-competitive procurement for “clones” of the Imager and Sounder instruments developed for flight on GOES-I/M. This cost plus incentive fee/award fee contract was awarded to ITT on August 13, 1996. The Imager and Sounder instruments will be provided to HSC as GFE for integration with the satellite. The major deliverables and contract features are:

a) The contractor is required to deliver two each of the GOES Imager and Sounder instruments
b) Two options for one additional Imager and Sounder each.
c) The contractor is also required to provide pre-launch, launch and post-launch support
b) Structured cost incentive
c) All fee tied to on-orbit performance of the instruments

11.2.2 GOVERNMENT FURNISHED EQUIPMENT

During the GOES-I/M development, the multi-layer insulation (MLI) blankets and the cooler cover doors for the Imager and Sounder instruments were provided by Space/Systems Loral (SS/L). ITT, therefore, has not developed the experience necessary to design and manufacture these items. The GSFC GOES Project Office has therefore determined that the most time and cost effective approach is to supply this equipment to as Government Furnished Equipment (GFE).

11.3 SOLAR X-RAY IMAGER

The prime contractor for the GOES-NO/PQ Solar X-Ray Imager instruments is the Lockheed Martin Advanced Technology Center in Palo Alto, CA. LMATC was competitively selected for a Cost-Plus-Incentive Fee/Award Fee contract. The SXI instruments will be provided to HSC as GFE for integration with the spacecraft. The contract deliverables and features are:

a) The basic contract is for the procurement of two flight model Solar X-Ray Imager instruments
b) A separate procurement option for one additional SXI instrument for use with the GOES-P spacecraft
c) A separate procurement option for one additional SXI instrument for use with the GOES-Q spacecraft
d) One SXI mass model
e) One set of Electrical Ground Support Equipment (EGSE) for use at NOAA/SOCC, and EGSE for use at the spacecraft contractor’s facility
f) One SXI Simulator for use at the spacecraft contractor’s facility
g) One SXI simulator for use at the NOAA/SOCC location
h) Structured cost incentive fee
i) Award Fee tied to meeting on-orbit requirements

11.4 PROJECT TECHNICAL SUPPORT

The GOES Project office will use support contractors to provide support as needed during the planning, preprocurement, and development phases of the program. This support will be provided on the basis of one or more Task Order support contracts, depending on the limitations of the GSFC civil service manpower available to the project.

12.0 PROJECT DEPENDENCIES

The GOES Project requires the use of a combination of major facilities listed below. The facilities will be used during prelaunch preparations, launch operations, in-orbit checkout and routine operations activity following satellite handover to NOAA.

Table 11.2.2-1

Function	Facility	Location	Organization
S/C Processing	PPF	Titusville, Fla	Astrotech
S/C Launch	Launch complex 17b	Cape Canaveral	USAF
Tracking Network	GN, DSN	MILA Madrid Canberra Goldstone	NASA/SOMO
Operations	SOCC	Suitland, Md.	NOAA
Data Acquisition	WCDAS	Wallops, Va.	NOAA
Data Acquisition Backup	CDAS	GSFC	NASA/GSFC
SXI Calibration	XRCF	Huntsville, Ala.	NASA/MSFC
SEM/SXI Data Acquisition	SEC	Boulder, Co.	NOAA

Payload Processing Facility: The payload processing facility at Astrotech is required to test the spacecraft after shipment and prepare the payload for launch. This includes fueling the spacecraft in the Hazardous Processing Facility.

Launch Complex 17B: The GOES-NO/PQ missions will be a commercial launch on a contractor-provided Delta III launch vehicle which launches from complex 17B. KSC is responsible for provide insight into the launch vehicle production and processing. . It is the responsibility of HSC to arrange for Government access to its subcontractor for the insight program.

Tracking Network: The tracking network is used to provide spacecraft telemetry to the NOAA SOCC in support of launch and orbit raising operations. The DSN is used during the mission operations phase for ranging and orbit determination.

Satellite Operations Control Center: The Satellite Operations Control Center in Suitland, Maryland will be used to support the operational phase of the mission after satellite handover to NOAA. This facility will also be used during the spacecraft test program to verify the GOES-NO/PQ operations equipment and validate compatibility with the NOAA ground system

Command And Data Acquisition Station: The NOAA Command and Data Acquisition Station (CDAS) is located at Wallops, Virginia and will be used to perform data acquisition and telemetry and command operations with the operational satellites.

Backup CDA Station: The NOAA backup command and data acquisition station will be located in Building #25 at GSFC.

Space Environment Center: The SEM and SXI data are received and processed by the NOAA Space Environment Center at Boulder, Colorado. Data collected from the SEM instruments include measurements of the variability of the geomagnetic field at the satellite, the emission of x-rays from the Sun, and the strength and concentration of charged particles from the sun. The SEM data are used for predication and monitoring of solar activity and its effects on the Earth’s environment.

XRCF Calibration Facility: The XRCF is required to complete the SXI calibration.

13.0 AGREEMENTS

13.1 GENERAL

The agreements that are necessary for project success, and their projected dates of approval are described below.

13.2 NOAA AGREEMENT BETWEEN NASA AND NOAA

The basic agreement between the National Aeronautics and Space Administration and the U.S. Department of Commerce Concerning Collaborative Programs is included in Appendix A.

The Memorandum of Agreement Between the National Aeronautics and Space Administration and the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce for Cooperation in the Geostationary Operational Environmental Satellite (GOES) Program is also included.

13.3 MARSHALL SPACE FLIGHT CENTER MOA

Agreement Between the Goddard Space Flight Center(GSFC) Geostationary Operational Environmental Satellite (GOES) Project Office and the Marshall Space Flight Center (MSFC) X-Ray Calibration Facility (XRCF). This agreement is included in Appendix B

13.4 KSC LAUNCH SERVICES MOU

The agreement between GSFC and KSC for the Launch Vehicle and Launch Services procurement activity is described in Appendix C.

14.0 MISSION ASSURANCE

14.1 GENERAL

The GOES-NO/PQ Mission Assurance (MA) program will ensure that both lifetime and performance requirements are met by the flight and ground hardware and software.

14.2 QUALITY MANAGEMENT RESPONSIBILITY

Responsibility of all GSFC personnel that affect final quality of all GOES products will be documented in procedures and work instructions in accordance with Goddard Procedures and Guidelines (GPG) 1410.1.

14.3 PROJECT SURVEILLANCE PLAN

The contractor's work activities, operations and documentation shall be subject to review and evaluation for conformance to their documented MA program and ASQC/ANSI Q9001-1994 by NASA representatives at their facilities and other locations (e.g., spacecraft contractor's facilities) in accordance with a Project Surveillance Plan.

14.4 DOCUMENTATION ACCESS

The contractor shall provide to NASA representatives, in-plant access to documentation and information related to MA activities, including those related to system safety, parts, materials and processes, reliability analyses, printed wiring board coupons/analyses reports, and Failure Review Board (FRB) and Material Review Board (MRB) activities and reports.

14.5 HARDWARE AND SOFTWARE FLIGHT HERITAGE

The contractor is encouraged to incorporate flight heritage hardware and software into the GOES-NO/PQ program to the fullest extent possible.

14.6 FAILURE REVIEW BOARD

The contractor shall convene and conduct Failure Review Board (FRB) meetings to review reported failures and to determine actions to be taken to investigate, follow-up, and close out failures. The program product assurance manager or his designee shall chair the FRB. Other members shall include the responsible unit or subsystem engineer, system engineer and reliability engineer. Specialist support shall be provided as necessary to adequately present and review the failures under consideration. As chairman, the contractor Program/Product Assurance Manager shall ensure that:

a) Failure reports are timely, accurate and complete
b) Open reports are reviewed regularly and closure plans are developed and executed
c) Causes of failures are determined and proper analysis has been conducted
d) Effective corrective action is being taken
e) Each failure report and failure analysis report is reviewed and accepted
f) Closeout actions are completed

Subcontractors shall be required to implement a failure reporting system in support of the HSC system. Subcontractor failure report forms may be used to report failures and corrective action when approved by HSC. When failures occur during acceptance testing, the subcontractor shall be required to notify HSC within 24 hours. An initial copy of a failure report, if not submitted as part of the 24-hour notification, must be submitted to HSC within 5 working days after occurrence of failure. The documentation, investigation, analysis, and closeout of failures shall meet the same basic requirements as are prescribed for the HSC. The program FRB shall review subcontractor failure reports and closeout actions.

Mission On-Orbit Performance Metrics shall be maintained and reviewed to provide updates as to the overall performance of the current spacecraft fleet. A centralized database is established to capture and track critical mission/on-orbit problems. An enterprise-wide corrective action board, consisting of senior management from each of the product and customer business units, convenes on a periodic basis to identify, review, and prioritize mission/on-orbit problems and ensure that both existing and potential problems are being solved.

15.0 RISK MANAGEMENT

15.1 SPACECRAFT

The risk management plan for the GOES-NO/PQ spacecraft includes a process that examines and ranks all potential programmatic, technical, schedule and cost risks in a systematic fashion. Using this process, items are identified that represent the greatest risk and then used to prepare a program watchlist. The watchlist is reviewed and updated on a regular basis throughout the program. The GOES Integrated Product Team structure ensures customer involvement and control in design, test, requirements compliance, and schedule of all new and unique items. All IPTs are responsible to fulfill several risk management roles including:

a) Identify assess and prioritize risk items
b) Develop, document, and submit risk mitigation plans
c) Recommend changes that could reduce risk
d) Implement risk mitigation plans, track progress, and report status

15.2 REPLACEMENT MISSION

The spacecraft contractor shall provide a replacement mission, at no change to contract price, for a maximum of two replacements in the basic contract and one replacement in each option, in the event of the failure of any GOES-N,O,P or Q spacecraft.

The spacecraft contractor shall provide a replacement mission, at no change to spacecraft price, if the interface to the Imager (including INR functionality) fails during the first year of operations.

15.3 PAYBACK PROVISIONS

If any of the eleven spacecraft fail during the required mission lifetime, the spacecraft contractor shall payback to the Government an amount defined in the contract.

16.0 ENVIRONMENTAL IMPACT

GSFC program/project managers are responsible for implementing the requirements under the National Environmental Policy Act (NEPA) in accordance with NASA's policy and procedures (14 CFR Part 1216 and NPG 8840). NEPA requires that environmental factors/impacts be considered in the decision making and planning process of program and projects. Managers shall ensure that the NEPA process is implemented early in the program development and execution.

An environmental evaluation, or preliminary review of the project, shall be performed to determine the level of NEPA documentation required. Based on the review, a Memorandum For File for a Categorical Exclusion, or an Environmental Assessment, or an Environmental Impact Statement shall be prepared.

17.0 SAFETY

17.1 INDUSTRIAL SAFETY

The safety procedures and requirements to be followed in implementing the GOES-I/M Project are in response to, and in accordance with, the policies and guidelines set forth in the Health and Safety Program, GMI 1700.2B; Basic Safety Manual, NHB 1700.1 (VI); and with the overall GSFC policy of avoiding injury to people, as well as property loss, to the maximum extent practical. To this end, the following measures will be implemented. It is GSFC policy to inform affected personnel of any hazards resulting from involvement in this Project, and to provide all requested hazardous material information.

- Inclusion of the Safety and Health Clause contained in the NASA Procurement Regulation 1.5204 in all resulting GOES contracts
- Submission of industrial safety plans by contractors for review, comment, and approval by the GOES Project with assistance given by the GSFC Health, Safety, and Security Office
- Compliance with applicable chapters of the Code of Federal Regulations and the National Environmental Protection Agency codes when using, handling, storing, or transporting dangerous materials
- Compliance with Range Safety Manual, Air Force Eastern Space and Missile Center/Air Force Western Space and Missile Center (AFESMC/AFWSMC) document 127.1 and KSC Safety Program, Kennedy Management Instruction (KMI) 1710.1; and any applicable launch vehicle restraints manuals
- Accomplishment of final review of all aspects of Mission safety in accordance with the GSFC Design Review Program and in compliance with the Systems Safety Plan

17.2 RANGE SAFETY

Range safety shall be in compliance with EWR-127-1.

17.3 SYSTEM SAFETY

The GOES-I/M Project will establish a comprehensive Safety Program for the entire Mission in accordance with System Safety for Flight Programs, GMI 1700.3. Project and ground support personnel, test and integration personnel and facilities, hardware and software, and Mission operations will be covered. The end-to-end system approach is described in NHB 1700.0 (VI—A), and System Safety, NHB 1700.1 (V3).

18.0 TECHNOLOGY ASSESSMENT

The hardware required for the GOES NO/PQ project is well within the state of the art. The Imager and Sounder instruments are the same as the instruments developed for GOES I/M with minor changes due to parts obsolescence. The spacecraft bus is based largely on the HSC 601 spacecraft, which has flown many times. The launch services will be commercially procured by HSC.

19.0 COMMERCIALIZATION

There are no known commercial applications or products associated with GOES data. The GOES data is freely disseminated by NOAA.

20.0 REVIEWS

20.1 EXTERNAL INDEPENDENT READINESS REVIEW

An External Independent Readiness Review (EIRR) will be held at the spacecraft contractor’s facility prior to the launch of each satellite. The purpose of the review is to have an independent panel of experts review the launch readiness of each satellite and launch vehicle. The detailed description of the EIRR is described in CDRL PM-1.3-06.

20.2 INDEPENDENT ANNUAL REVIEW

The program will be reviewed annually by an independent team appointed by NASA Headquarters. The purpose of the review is to assess progress toward meeting the commitments contained in the PCA. This independent team reports its findings to the NASA PMC.

20.3 SPACECRAFT FLIGHT ASSURANCE REVIEWS

Indicated below are the reviews that will be conducted by the GSFC Systems Review Office. The Design Review Program (DRP) summarized below is described in more detail in the Contract Data Requirements List (CDRL)for the Geostationary Operational Environmental Satellite Program, S-415-26.

Table 20.2.2-2 Spacecraft Review Requirements

Review	CDRL Reference
System Concept Review(SCR)	SE-2.1-01
Preliminary Design Review(PDR)	SE-2.1-02
Critical Design Review(CDR)	SE-2.1-03
Mission Operations Review(MOR)	SE-2.1-04
Pre-Environmental Review(PER)	SE-2.1-05
Pre-Shipment Review(PSR)	SE-2.1-06
Flight Operations Review(FOR)	SE-2.1-07
Launch Readiness Review (LRR)	LV-3.8-25

20.4 LAUNCH VEHICLE REVIEWS

The Launch Vehicle program review requirements are summarized below and are described in the CDRL document S-415-26.

Table 20.2.2-3 Launch Services Reviews

Review	CDRL Reference
Mission Integration Program Kickoff Review	LV-3.8-07
Requirements Review	LV-3.8-09
Component/System Design Review	LV-3.8-10
Mission Peculiar/Mission Unique PDR	LV-3.8-11
Mission Peculiar/Mission Unique CDR	LV-3.8-12
Pre-Installation Review	LV-3.8-16
Final Loads Verification Review	LV-3.8-17
Pre-Shipment Review	LV-3.8-20
Senior NASA Management Mission Readiness Review	LV-3.8-23
Pre-Payload Mate Review	LV-3.8-24
Launch Readiness Review	LV-3.8-25

20.5 IMAGER/SOUNDER REVIEW REQUIREMENTS

Project Status Reviews:
The Imager/Sounder review requirements consist of the Project Status Reviews that are described in CDRL item 1-01. The program financial status is also reviewed during the MSR meeting activity.

The Project Status Reviews will be held bi-monthly, or as required by the GSFC Contracting Officer’s Technical Representative (COTR).

Flight Assurance Review Program:
The Flight Assurance Review Program for the Imager/Sounder Instruments shall consist of a Pre-Shipment Review for each flight instrument

20.6 SOLAR X-RAY IMAGER REVIEW REQUIRMENTS

Indicated below are the review requirements for the Solar X-Ray Imager. The detailed description for each review is described in the S-415-13 Statement of Work for the SXI instrument.

a) System Requirements Review (SRR)
b) Preliminary Design Review (PDR)
c) Critical Design Review (CDR)
d) Pre-Environmental Review (PER)
d) Pre-Shipment Review (PSR)

21.0 TAILORING

NOAA controls program objectives, requirements, schedule and funding for the GOES Program. NOAA provides formal direction to NASA at least twice per year on a special schedule to accommodate the NOAA/DoC budget schedule. Schedules and funding remain somewhat flexible to respond to the on-orbit performance needs of the operational satellite program. The schedule and cost commitments contained in the PCA, PCC, Program Plan and Project Plan will be updated after each budget cycle. This will ensure the latest NOAA requirements are reflected in these documents in a timely manner and that NASA management at all levels is working to meet our customer’s needs.

Schedule and cost commitment changes will be recorded in the activity logs of each of the documents and shall not require notification of the approving official. The Lead Center Director's signature on the formal transmittal letter to NOAA shall constitute authority to update these documents with the new cost and schedule commitments. Any changes other than those directed by NOAA shall require the signature of the appropriate approving official.

22.0 CHANGE LOG

Change	Date	Description

23.0 APPENDIX A NASA-NOAA BASIC AGREEMENT

BASIC AGREEMENT BETWEEN THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE U.S. DEPARTMENT OF COMMERCE CONCERNING COLLABORATIVE PROGRAMS

MEMORANDUM OF AGREEMENT BETWEEN THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION OF THE U.S. DEPARTMENT OF COMMERCE FOR COOPERATION IN THE GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE PROGRAM

24.0 APPENDIX B GSFC-MSFC SXI CALIBRATION MOU

INTRA-AGENCY AGREEMENT BETWEEN GEORGE C. MARSHALL SPACE
FLIGHT CENTER (MSFC), ALABAMA 35812
AND
GODDARD SPACE FLIGHT CENTER, GREENBELT, MD 20771
FOR
THE TESTING OF THE SOLAR X-RAY IMAGER (SXI) INSTRUMENT

25.0 APPENDIX C GSFC-KSC MOU

MEMORANDUM OF UNDERSTANDING BETWEEN GOES PROJECT, GODDARD SPACE FLIGHT CENTER
AND
ELV LAUNCH SERVICES PROJECT, KENNEDY SPACE CENTER
FOR
GOES-NO/PQ LAUNCH SERVICES GOVERNMENT INSIGHT / SUPPORT

26.0 APPENDIX D

GOES N-Q MASTER SCHEDULES

APPENDIX D
GLOSSARY

- Geosynchronous-Term applied to any equatorial satellite with an orbital velocity equal to the rotational velocity of the earth. The geosynchronous altitude is approximately 36,000 km above the earth’s surface. To be geostationary as well, the satellite must satisfy the additional restriction that its orbital inclination be exactly zero degrees. The net effect is that a geostationary satellite is virtually motionless with respect to an observer on the ground.

- INR System-The Image Navigation and Registration (INR) system compensates in real time for the effect of orbital motion and attitude variation on visible and IR images.

- Image Navigation-Image navigation is the process of determining the coordinates of each pixel within an image in terms of earth longitude and latitude; i.e., absolute pointing accuracy.

- Image Registration-Image registration is the process of maintaining the coordinates of each pixel at the same earth longitude and latitude independent of time; i.e., measure of pointing stability.

- Within-Frame Registration-Relative navigation error between any two picture elements (pixels).

- Frame-to-Frame Registration-Maximum peak-to-peak navigation error of the same pixel over a specified period of time

- Level I Requirements-Top level performance requirements, which are few in number, approved by Headquarters and are eventually used to assess the success of the mission. (Note: This definition is contained in the GSFC document titled The NASA Mission Design Process, Prepared by the NASA Engineering Management Council dated December 1992)

- NEDN and NEDT are radiometer noise figures of merit. The larger these figures of merit are the noisier the instrument is. NEDN and NEDT relate the noise in the same units as the scene.

27.0 APPENDIX E CURRENT BUDGET

28.0 APPENDIX F CURRENT MANPOWER PLAN